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ABSTRACT

A primary science program was developed over a 2-year period at a Montessori school. The program is intended to encourage creative but logical thought and active participation by the child in learning "hows" and "whys." It teaches the mathematical operations (measurement and comparative notation) necessary to know what to do with scientific information acquired in later study. The program consists of a series of problems (getting a stick the same length as a line on the chalkboard, making charts, etc.) the students discuss and experiment with. Shelf material and games are provided for the children to use anytime during the day. The children with whom the program was developed were relatively bright students of kindergarten age. The program is judged to be more suitable in most instances for first grade. Appendix I provides games and charts, and Appendix II shelf material and graphs. A bibliography of children's books is also given. (KM)

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A BEGINNER'S APPROACH to SCIENCE with LINES, GAMES and CHARTS

by Susan Merritt LaRoche

PS 006310

Submitted in partial fulfillment of the requirement for the M.A.T. Science Degree, Webster College, Webster Groves, Missouri 1970

coryright Susan Merritt LaRoche 1970

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FORWARD

The goals of a primary science program, as I see them, are 1) the encouragement of creative yet logical thought; and 2) active participation by the child in learning the "hows" and the "whys" within the proposed unit of inquiry.

Science should be taught in the primary grades not because science provides a necessary storehouse of factual data; but because it provides a singular area of study which can validly "teach" creative thinking.

> "Science is one of the few diciplines whose wealth of phenomenon is open to direct observation, manipulations and to the opperation of both intuitive and rigorous logic" (Kuslan and Stone. Teaching Science To Children. p. 160)

Creative thought in my estimation is a vital component of any endeavor, intellectual or other. It is also a fundamental clue to the development of self-confidence and a positive self-image; both of which are prerequisites for a receptive mind. By allowing students to "act out their mind" as well as their ego, interest doubles and children become confident in their own abilities. Being allowed to think and to do is an indirect signal of respect. This in turn effectuates a positive learning situation which makes "learning" and "knowing" fun. Contrast this with the stultifying inactivity of rote-learning under a competent model who is continually a source of intimidation.

If a child is to be able to understand, interpret and generalize the "hows" and the "whys" of science, then the curriculum must take into account the intellectual abilities of the age group. I don't mean individual differences, but the actual developmental level of the brain. In the kindergarten-first grade grouping the storehouse of information, the frame of reference and most importantly, the ability of the brain to manipulate data is slim and still inchoate. However, this initial intellectual development is marked by highly receptive and acquisitive strength.

It is for these very reasons that children are always handling, tasting, kicking and generally investigating everything. They are using all of their other senses to assist their brain in learning about the world around them. Children need to manipulate the thing that they are learning. They need a multitude of concrete "things" that represent, reinterpret and visualize these concepts which are intended to be learned. Information that is given out for memorization does no harm; some of it eventually finds an application. However, the greater benefit in trying to teach effectively is to build your curriculum on objects that represent it. Then allow the children the freedom to explore, handle and investigate the material that actualizes the abstract ideas which you would have their minds assimilate.

I have stated what I think the underlying goals of science in the elementary grades should be. Now, why choose a theme of linear measure, charts and elementary graph notation, if these point to math not science? My answer to this is that measurement (quantification) and comparative notation is the language of science. Mathematical operations are the means by which that language is made effective. In the same way that a child must first learn how to read before he can read for information, a child will know more what to do with scientific information if he has already a foundation for knowing what can be done with it and how to go about doing it.

And then, why limit oneself to just linear measurement, charts and records with some basic science application? The most important reason is that a teacher needs to challenge but not surpass the mental level of the children with whom she is dealing. The greatest effort is extended to the maths and recording of data. The scientific application follows easily.

If one attempts to approach "measurement" in a creative, investigative manner and allow the full benefit of active participation, it must be realized that more time, much more

time, is needed to reach the established goals. If children are going to be made responsible for the greater percentage of what they learn and how they explain it, then they must be given the time needed to manipulate, hypothesize, manipulate again, reason, think and try the same conclusion in various ways. I'm sure even a firm believer in this method has many feelings about "wouldn't it just be easier to tell"...? This of course is not the point. With children the value is not with the facts but in the "doing" and allowing him to lay claim to his own powers of reasoning. A child who has been encouraged to think, to reason and to rely on his abilities has conquered the greater part of that which is education.

> "One should never cram young minds with facts, names and formulae. To know them you have no need of university courses, you can find them in books. Education should only be used to teach young people to think and to give them this training which no textbooks can replace."
>
> (Einstein, Albert (in Albert Einstein by Hilaire Cuny). p.147)

Bibliography:

Kuslan and Stone. Teaching Children Science: an Inquiry Approach. Wadsworth Publishing Co: Belmont, California. 1968.

Cuny, Hilaire. Albert Einstein, The Man and His Theories. Fawcett Publications: Greenwich, Conn. 1960.

PREFACE

The program which follows was developed over a two-year period in a Montessori school. The children who taught me how and what they could learn were relatively bright students of kindergarten age. Many of them attended school full day and had previous Montessori training. By the second semester the children were able to read and write with understanding, were very well along in all phases of maths and had put to memory skip counting by "2s", "5s" and "10s". In general they were very eager to learn and quite well aware of the world around them. This should be kept in mind in reading over the curriculum, since it may seem in places to overestimate the abilities of the kindergarten age. In most instances it would be more suitable for first grade.

Since a Montessori school is ungraded, the group doing "measurements" numbered ten at the most, which provided the ideal circumstance for allowing each child's individuality to be known.

A special time, but not everyday, was set aside to do "measurements"; however, the children could work anytime during the day on shelf material and games. No specific time limits were set. After a discussion, perhaps some children worked for twenty minutes on projects, while two may have spent an entire afternoon. Others were free to work on unrelated activities. These ideas were kept in mind:

1) Although it is not emphasized in the pages to follow, whenever possible, ask the children to guess or "hypothisize" what the answer will be. This gives a decided sense of involvement and genuine interest in finding out the real result.

2) Attempt to get a more through understanding by varying the circumstances with a) "What do you think would happen if?", b) "What will it look like if you use this instead of that?", c) "Can you think of another way to do it?", d) get several groups

of children doing the same project separately so that the results can be compared, e) remember to get the children to verbally interpret their chart work; this will help them to better understand what they have done, f) allow children to work individually or in partners whatever and whenever they decide, g) if any problem arises which another child can solve, let him. Children can better understand and interpret the problems of their peer group.

3) Try to keep from restating the answers (right or wrong) that a child gives. If he has given a correct answer and you restate it, you are indirectly taking the credit for what he has said; or holding an incorrect answer up for ridicule. Both cases undermine self esteem. If children are interested, they will be listening and if they are listening, they will have heard what a peer has said without having it repeated. They will also be more willing to discuss and consequently show more overall interest if there is not a domineering "know it all" in the "crowd"...you, the teacher.

4) Materials must be organized and many things made by the teacher. (see games and shelf material) This takes time but little expense. The children will find many things in the classroom which can be used for measuring devices. However, a large store of "things" should be available e.g. beads, blocks, tiles, stick lengths, string, wire, bottle caps, toothpicks, paperclips, plus the things that the children name. You will specifically need: sissors for all, clay, colored tape, tack board, many colors of construction paper, and different sizes of squared paper (1 inch and ½ inch). The only recommended purchases are approximately one hundred each of three colors of unifix beads. These are two cm square, plastic interlocking cubes. (since the expense is somewhat great, you could manage with fifty of three colors)

available from: Responsive Environments Corp.
200 Sylvan Avenue
Englewood Cliffs, New Jersey, 07632
Price: 100 cubes @ $4.00

A. Daigger and Company
159 W. Kinzie Street
Chicago, Illinois 60610
Price: 100 cubes @ $5.50

Excerpt

Jos (6;11) "It's the same height.---Are you sure just by looking?---Yes, you can't go wrong.---Can you tell with your hands?---No, you'd have to put it there(both on the same table). ---Can you measure? Have you been shown how?---Yes, but I only know how to measure myself: you put a ruler up here (points to his head), you make it go all the way down and then you look.--- And can't you measure the tower with this stick?---No."

Piaget, Jean. The Child's Conception of Geometry. New York:Basic Books, 1960. p. 42.

(the above is the reaction of a child who has attempted to duplicate the height of a block tower built by the examiner)

THE TEXT

Throughout the text the general procedure will be as stated below. The teacher will certainly have to make adjustments according to the group of children with whom she is working. Above all the purpose in all cases should be to clarify and to work with the problems and suggestions offered by a particular class. Although the outline below and in the text seems rather repetitious, the reason is that in all too many cases, children are expected to understand and to know after being given only one or two examples. Anyone who has really followed up what is actually being learned by the children in such superficial programs finds that very little has really been internalized.

1. To present a problem
2. To make a judgment and to take action
3. To check the accuracy of the action against the problem
4. To discuss the results of the "collective action"...each child reassessing his own original judgment.
5. To repeat a similiar activity
6. To organize data
7. Individual exercises, games and variation found in appendixes I and II
8. Application (this may be included in the individual exercises, in recording data or how it integrates with further problems.)
9. Picture books, story books and reading matter, found in appendix III should be available at all times; some books are particularly relevant to certain activities. (See OUTLINE) These can be read, in part, to the children.

SECTION ONE: PROBLEMS

PROBlems as such are meant to be an activity for one day. A PROBlem e.g. 5, 5a, 5b; would be inclusive of <u>one problem</u> (or one day's activity). After initiating shelf activities, small group activities and games; it will be up to the teacher to judge the progression and concentration span of the children who are working at individual acitivites. She will make the decision as to whether to call for a discussion or introduce a new PROBlem to the group as a whole.

CORRELATED CUTLINE (the number after the entry indicate page number

exept fo

PROBLEMS

1. To get a stick the same length as the line on the chalkboard--9

2. To cut a strip of paper the same length as the line on the chalkboard--11

3. (Repeat) To get a stick the same length as the line on the chalkboard...use of clay base chart--12

4. Accuracy in Measuring... Goldilock's String Game--14

THEORY--14

5. >< Symbolic Notation--17

6. Random lines with > < notation--20

7. Different Way to Measure--21
   a) straight lines
   b) random lines

GAMES

1. Guess and Measure--35

2. Pot of Silver--36

3. Measure Lotto--37

4. Guess How many unifex and Match (paperclip score chart--39

5. Match My Stick (score card)--40

6. Go and Take--41

SHELF

1. Leaves

2. Element
tray--5

3. Control
signs--

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5. Mimeo
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except for books which are listed in the bibliography

SHELF MATERIAL

1. Leaves in a bowl--56

2. Elementary >< sorting tray--57

3. Control board with >< signs--57

4. Arranging >< sticks--57

5. Mimeo papers using >< signs--57

6. Mimeo paper...measuring lines to color--58

7. How Many? (measurement of different lines)--59

BOOKS

Schneider. How Big is Big

Licnni. Inch by Inch

Ford. History of Measurement (a poster)

Shapr. Lets Find Out What's Big

Kessler. What's in a Line?

MacAgy. Going for a Walk With a Line

Carona. Things that Measure

Benedick. How Much How Many

Epstein. First Book of Measurement

PROBLEMS

GAMES

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8. Measure
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9. Can You
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10. The Eg
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11. The Pr
Lung--

12. The P
64

13. The P
Short

GRAPH THEORY (inclusive of science ideas to be used as shelf materials)

8. Measuring lines to form a chart--27

9. Making a chart--28

8. Graph game 1--43

9. Graph game 2--44

10. Shoot and Chart--45

11. Race and Measure--47

12. Race and Measure variation with datagram--48

14. Obsta
--68

10. Developing a Standard--30

11. Developing a Standard, 2--31

THEORY ON THE STANDARD--49

From Here on Measurements, Charts and Graphs are all done with

the Standa

13. Car Racing--50
a) Introduce Find, Kaiser
b) Introduce Find, Kaiser, dinky
c) Introduce Find, Kaiser, dinky medor

15. Find,

16. Kind,
worksh

17. Find,
worksh

II

SHELF MATERIAL

8. Measure the floor...gummed loop project--60

9. Can You Guess Who's Shoe, and variations--61

10. The Egyptians Had a Way To Measure--62

11. The Problem of Farmer Lang--63

12. The Problem of Mr. Black--64

13. The Problem of the Shortcut--66

14. Obstacle Measure: chart --68

the Standard Measure

15. Find, Kaiser worksheets--69

16. Kind, Kaiser, dinky worksheets--70

17. Find, Kaiser, dinky, medor worksheets--71

BOOKS

Benedick. How Much How Many

Adler. Giant Golden Book of Mathematics

Epstein. First Book of Measurement

Hogben. The Wonderful World of Mathematics

Luce. How Much How Far How Many

Asimov. The Realm of Measure

PROBLEMS

GAMES

SHELF M

14. Mystery Maps--53

15. Treasure Hunt--54

18. PROJ
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19. Mapp

20. Magn

21. Measu
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22. Measu

23. The
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25. Measu

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27. The
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28. How
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III

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aps--53

unt--54

SHELF MATERIAL

18. PROJECT: Making a standard tape measure--72

19. Mapping in Finds--73

20. Magnet strength--75

21. Measuring the periphery of leaves--76

22. Measuring Shells--77

23. The Measurements of a Stem--78

24. The Diameter of a Balloon versus temperature--80

25. Measuring Shadows--82

26. Height versus Distance--83

27. The Case of the Vanishing Bar of Soap--85

28. How Much Water Boils Away?--86

III

BOOKS

Barr. More Reasearch Ideas for Young Scientists.
"Does a Rubber Band Stretch Evenly?" pp. 149-150
(An experiment and graph of length versus weight)

P.C.B. 1: Draw a line segment AB (approx. 5-9 inches) on the chalkboard. Ask the children to go outside and get a stick which is the <u>same length</u> as this line.

PURPOSE: The children are asked to solve a problem... the solution to which lies in a method. To arrive at a method requires analytical thought. Since the mind of a child has not yet deduced a system of rational actions, it remains to initiate situations which attempt to activate the rudiments of logic. The teacher should allow each child to confront the PROBlem unaided by suggested solutions. A teacher's help in this situation merely stultifies the mind in persual of its own function. The absence or presense of a child's method (by a child's standard) will determine the basis of the discussion and form a beginning to the considerations and variations contingent to the linear propagation of a line.

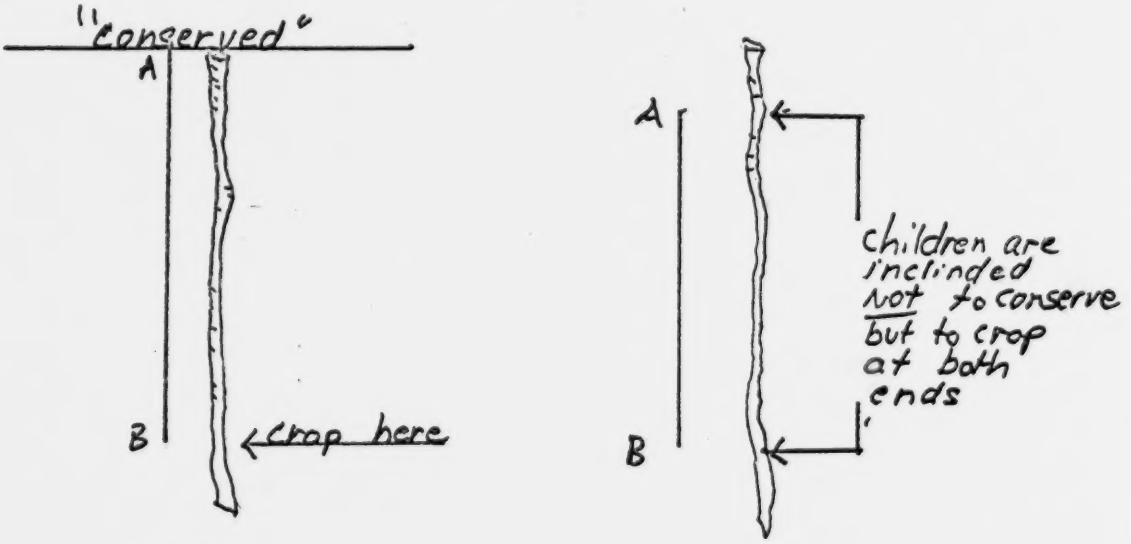
The essential point is to involve each child <u>individually</u> and by <u>his own</u> device in the initial action,- getting the stick. In this way each child has a vested and personal interest in the activity and its results. If learning is to be authentic, then it must be derived from the direct application and concerned participation of the SELF to the situation.

The DIScussion which will follow the activity will provide a cognitive "pool" of the abilities range. The teacher should refrain from making value judgments. Her position is that of a listener and interrogator, in general a director of the affairs, channeling ideas to a constructive end and encouraging total group participation. The perceptual→conceptual abilities of this age child have been taken into consideration in the outline of the activities. Therefore, during the discussion, the teacher should concern herself with developing analytical and logical thought, rather than with "<u>teaching</u>!".

DIS: (pertinent to PROBlem 1) Undoubtly most, if not all of the children will have rushed outside and obtained a stick. Most sticks will be of a length which show a reasonable approximation. The accuracy which is lacking---the reasons why it is lacking---and the steps which may be taken to correct the inaccuracy, will be the the topic of discussion. In checking their sticks against the original line AB the children will gain insight into the meaning of "too short", "too long". As the children talk about the results the teacher will find that a child in expressing an idea may be finding it difficult to put himself across because he lacks the word which would clarify his thoughts. In such a situation the teacher gives the word e.g., "measure" for the definition which the child has already made. Any learned vocabulary is inserted as the need arises i.e., it is not a need in itself.

Through the discussion and the activities of their peers, it will become apparent to all that in measuring or comparing a line, in this instance AB, that the instrument used for comparison must be "conserved" at one end, while cropping the excess at the other end.

Example:



PROB.2: Draw a line, AB, on the chalkboard. Ask children to cut a strip of paper which is the same length as the line AB on the board (Materials: long strips of paper or string, sissors)

DIS: The discussion will undoubtedly center about how some of the children were able to come up with a correct and quite nearly accurate length. (Being in the immediate circumstance, many will have used the line on the chalkboard as a guide while they cut their strip directly beside the line AB. In a sense they are using the "Kings standard" as their gauge, having no duplicated replica of their own). In the discussion, the children should be led to realize that the length of a thing can be and for the most part is independent of that thing.

The child has now in his possession a string the length of AB (the hypothetical standard). This in itself represents a gauge or calculator. The possession of the string gauge provides a means of "transporting" the constancy of an idea i.e., he now could go anywhere and obtain any number of things which would be the length of AB. Try above all to get the children to arrive at these ideas by oral expression, e.g.:

"Mary, can you prove that your string is the same length as AB?"

"Yes." she does so.

"Would you be able to go to the store and get a ribbon the same length as AB?"

"Hmmm, I don't know?"

"What is the problem? Is it that you would not be able to remember the length of AB after you got to the store?"

"Oh, I know! I could just take the string with me to remember."

(Whether the child says "yes" or "no", have him explain himself. In this way you can be sure that he understands what you meant or that you have not misinterpreted him. It is best never to announce that a child is "wrong"; stay with the positive.

PROB. 2 a: <u>The need to maintain consistency</u>

Q. "If I erase the line (do), can someone redraw a line which is the same length?"
(this will easily be done)

Q. "How do I know it <u>is</u> the same?"
(any number of children will want to recheck, test and verify with their own string)

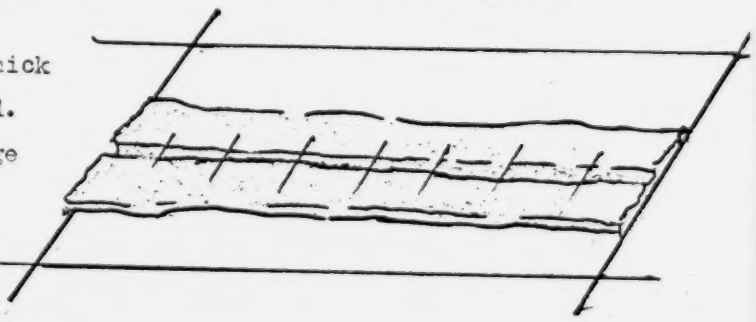
PROB. 2 b: <u>The need for keeping intact (saving)</u> tangible evidence of a quantity (at this time in lieu of symbolic notation e.g., "4"beans long) in order to reconstruct an accurate image of that which will be no longer in sight.

Q. "Tomorrow, the line will no longer be on the board, how will I remember how long it was...how will you remember?"

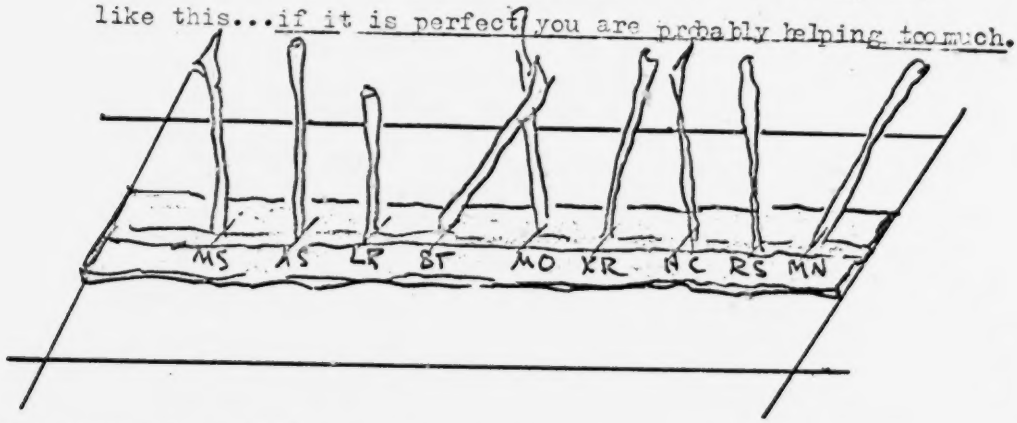
PROB. 3: To reconstruct line AB, check and verify the line from the evidence decided upon yesterday.

PROB. 3 a: From the reconstructed line AB on the chalkboard, ask the children again to go outside and find a stick that is the same length as the line. Perhaps you will have to initiate a short discussion before the activity. Try to encourage as many different methods as possible. The children by now will realize that a mnemonic device is a necessity. They will think of innumerable ways and means-- do not stifle any idea (it may be better than you think); futhermore, self-confidence in dealing with a problem will foster interest and involvement in the activity and in making further judgments.

PROB. 3 b: <u>Primitive bar line chart</u>, done with the actual material. Prepare a long narrow clay base approx. $\frac{1}{2}$" thick on a piece of art board. With an implement, gouge a very shallow groove the length, with cross scratches to keep equal spacing.



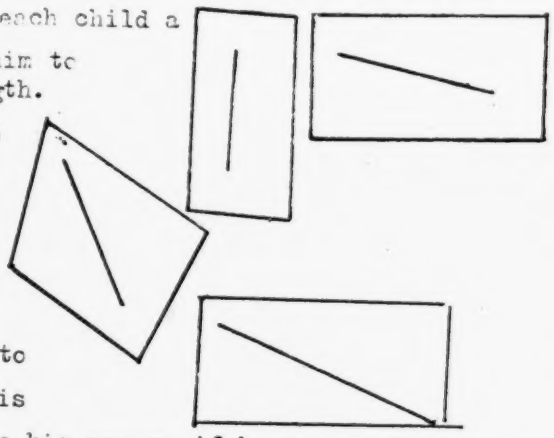
With some idea of "method", recognized in previous problem, the children will return with sticks. Curiously enough, they will be more dedicated in their efforts this time, so allow ample time for them to perfect the accuracy of their sticks. The teacher need not interfere except to interrogate, answer questions or perhaps assist in a manual way. As each child concludes that his stick is the proper length, he sticks it into the clay base, initialing with a toothpick. Despite all previous discussions: it will probably look like this...if it is perfect you are probably helping too much.



DIS.: discuss "graph" first; what does it show? Elicit every possible thought from all children; this will lead to the errors in accuracy (Don't point out their errors, but if they are not perceived you then ask leading questions.) Essential to this type of learning situation is that the children do the thinking and that they are kept actively involved in developing their own principles from their own point of view.

In the discussion of what the graph shows them, the basic precondition will have been noticed by children: all "lines" should stand perpendicular to a level base line.
(The ideas will be determined in their own words and should be jotted down for further reference.)

PROB. 4 (Playing with accuracy) Materials: string, sissors, approx. ten 4"x11" construction paper on which lines of various lengths have been drawn. Do not show too great a variation in the line lengths. Give each child a paper with line and tell him to cut a string the same length. Before checking recall the problem in Goldilocks and the three Bears: too hot, too cold , just right. (or too long , too short, just right) Going around to each child, he verifies his string length with that on his paper; if he is not "just right", Goldilocks (teacher, students) say "Goldilocks says too long." (or whatever) It will be found that "Goldilocks" is an inoffensive critic with whom it is more fun to co-operate. Each card and string having been checked, the teacher collects all strings and puts them in a box or "heap", and mixes the papers on the floor.



Game: Mun's turn: teacher picks a string and holds the length up...Mun must determine which line the string matches...once he has decided he can match the string to the line, "Goldilocks says "just right", then Mun gets to keep the string. Goldilocks says "too short or too long " and the string goes back into the box. The "winner" of course is the child with the most strings.

THEORY: The activities involved in making comparisons, measuring and recording serve the purpose of learning by manipulation. Hopefully the child will find these activities applicable to a scientific procedure. He is too young to do to much more than observe science but if he learns how to compare and observe quatitatively he is mentally capable of dealing

with that which he observes.

In this program we are working with three areas of learning: 1) the stage of mental development at this age is such that some types of perception, the forming of some concepts and the ability to generalize (in that order of difficulty) will of themselves prevent transfer learning or any real, as opposed to rote, abstractions to take place. However through the manipulation of concrete ideas and the stimulation of interest, children of this age are capable of benefiting from the "sense" of what they are doing. The "incongruity" level within the different activities, and how far they are pursued should provide a span great enough to interest a similarly vast range of abilities within a group of children of the same approximate age. The first area is learning to learn.

2) the children are learning to deal with a) a concrete in linear and geometric forms, b) an abstraction or number, c) the technique of measuring and recording their findings.

3) the children will be approaching what one generally conceives of as science (natural and physical) for no other inherent reason than that of measuring a quality or discovering some linear or geometric possibilities.

So far the very basic rudiments of approach have been introduced. Two further concepts are needed: a form of symbolic reference i.e. when one says"two inches" instead of always concretely representing it; and secondly, the necessity of developing a standard of measure. At this time both of these ideas will and should be kept somewhat at bay. The children will arrive at a point where the device or idea of them will become obvious in their application; hence, more meaningful. This is a natural sequence. Arrival at a standard of measurement from the primitives to the time of modern man (SEE BOOKS for History) has always been

through a similar line of reasoning. Even today, computations by conversion to another standard is common in weights and measures. It has only been by the development and continual developing of the subtlties of science that a uniform system of metrology and quantification among nations has come to the fore as an indispensible facility to the working scientist.

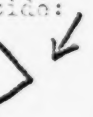
At this point introduce GAMES (Appendix I), SHELF MATERIALS (Appendix II), allow children the benefit of thumbing through some of the books (SEE: CORRELATED OUTLINE) listed in the BIBLIOGRAPHY for the childrens library. Read to them some pertinent selections.

Since all of the children will not be able to read sufficiently well, it may be necessary to "demonstrate" the procedure of a game or exercise. It will be most beneficial for the teacher to lead individuals, or small partner groups into variations of what they are doing. Ask them questions about their work and help them with recording. Introduce new PROBlems to fill a vacancy, lull in interest or need. The teacher should include additional PROBlems of her own as they arise from working with her particular group of children. A call for a discussion with a small group or for the group as a whole will follow from the dictates of need, the common sense and ingenuity of the teacher.

Do not interfere with the childrens work especially if they are concentrating, regardless of whether you think they are on the wrong track. If the child is involved in his work, he will soon find out whether he is stumped or not and he will then come to you. On the other hand, it may well be that you have not really observed <u>his method</u> which may be more creative and of better use to the child than your suggestion. Leave plenty of time for them to arrive at some type of solution or "learning"; it can never be assumed that having done something once, that it is known.

PROB.5: Introduce < > as a form of symbolic notation.

Draw < on the chalkboard, and ask the children to look at the sign and decide which side of the figure looks longer or more open than the other. (Talk about symbols: how they look, what they stand for.) Explain when this symbol is used, the lengths of its sides are representative, i.e. the littlest thing goes on this side:



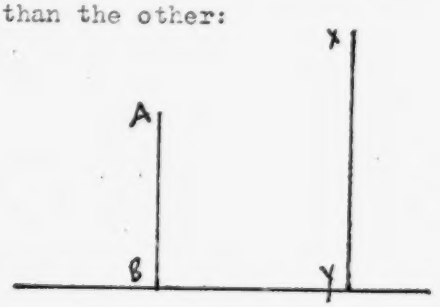
and the biggest thing goes on this side.

(Erase; put the sign the other way)

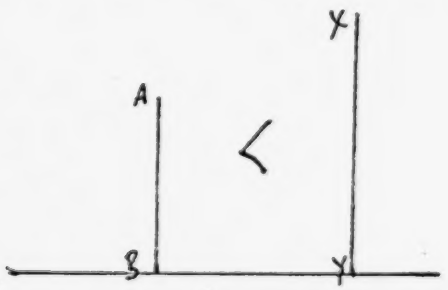
Ask which side the longest line would go on? (have a child put a long line on the proper side. Then ask a child on which side a short line would go. (Have him put a short line in that place.)

Explain that it does not matter whether the sign goes < or > ; you always put the bigger thing or number on the big side and the littlest thing or number on the small side.

PROB. 4a: Draw two lines on the chalkboard that visually show that one is longer than the other:



Ask a child to put a sign > or < between the two lines

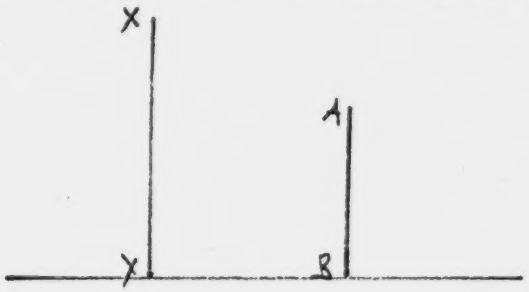


Then show immediately beneath: (line) AB < XY

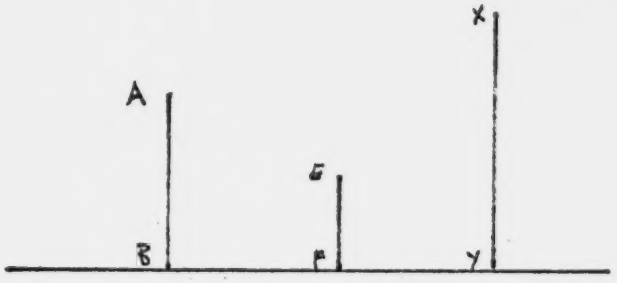
T.: Is that right? (Erase the picture, leaving (line) AB < XY)
Have a child reconstruct a picture that represents:

(line) AB < XY

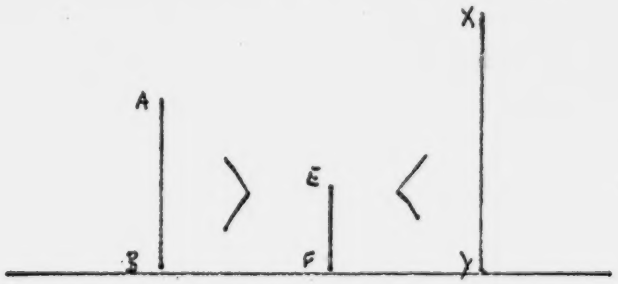
PROB. 5b: Repeat the entire procedure of PROBlem 4a; only use the opposite arrangement:



PROB. 5c: Reapeat the procedure using three lines:



Have the children insert the proper signs:



(Note: you may have to remind them that as in reading, we also read these notations from left to right.)

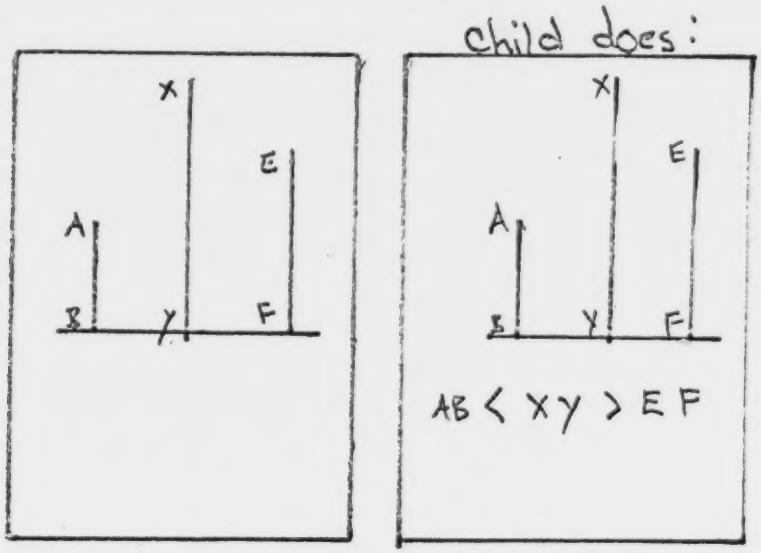
Do not erase picture; but write: AB > EF < XY

Then write the same in a different order: EF XY AB

Ask the children if they can figure out what sign to put between the three groups of letters.

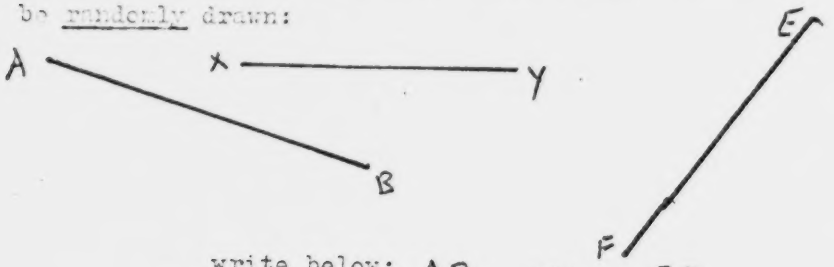
Try all possible combinations, having the children put the signs in the proper way.

Have a stack of papers: all with three lines that show visually which is bigger or smaller than the other. Leave room at the bottom of the page for the child's notation:



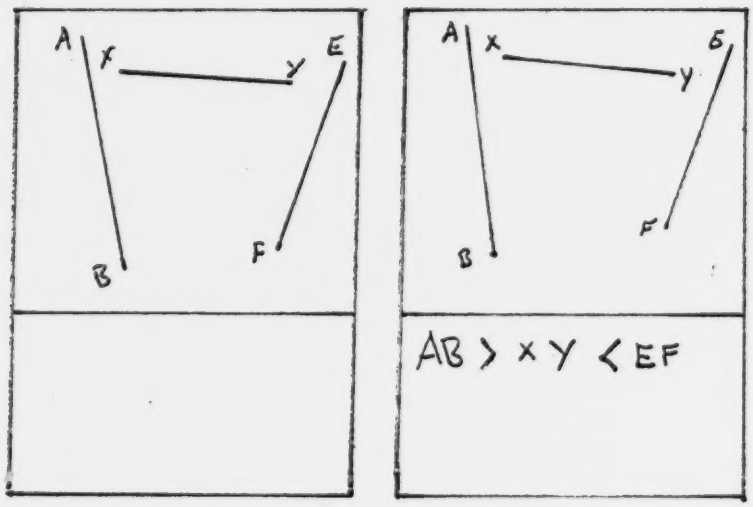
Each child can take one and put signs in the proper place and then write a statement below. Encourage each child to think of another arrangement for his statement which would also be correct. (Note: the remaining papers can be clipped together and placed out as shelf material, along with the other > < sign problems: SEE: SHELF MATERIAL.)

PROB. 6: Measuring to find out where to put $>$ $<$ signs.
Using chalkboard, again draw three lines. This time they should be randomly drawn:



write below: AB XY FE

Q. How are we going to know which signs to place between the three groups of letters that represent the lines? (The children may suggest that if lines were standing up straight, they could "see" or they may suggest measuring with string or some other means.) Work with the suggestions given, so that they can complete the statement: AB > XY < FE
Without erasing the lines or statement, ask for other ways to find an answer. Test each suggestion against the original on the board.
Again have a stack of papers; each with three lines randomly drawn and room below to write the statement:



(these too can be placed out as SHELF MATERIAL)

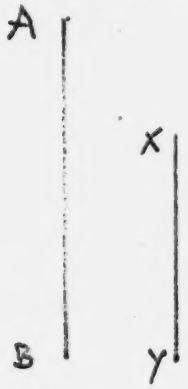
PROB.7: WAYS TO MEASURE

Draw a line AB on large paper or flat chalkboard.

Q. "Now if I want to write down how long the line is what will I write?"

DIS: Solicit as many plausible ideas from the children as possible. It may be that you will have to ask what different ways they can think of to measure...once begun, the children will think of innumerable items (units) to use: e.g., beans, toothpicks, paperclips, rocks, thumbtops, raisins etc. (Note: hereafter any unit of measure may be given a symbol, e.g., 2 tt (two thumbtops); 2tp (two toothpicks); rk (rocks); r (raisins))

Q. Now, if you have two lines AB and XY, (draw on paper or chalkboard) we can see that AB is longer than XY. But if I want to write down how long each is, we will have to use a "unit". If we use unifix, how long is AB? (have a child measure) How long is XY? (have a child measure) Write the answers under the lines.



DIS.: (presume) If AB is seven unifix and XY is five unifix and I erase the lines (do, but not the information) and just say line AB is seven unifix and line XY is five unifix... without seeing the lines, can you tell which is longer? (a quantity "7" is more than "5") How do you explain your answer? Any other ideas? Does anyone disagree? etc. Then we can say:

$7 > 5$ $\qquad$ $5 < 7$

$AB > XY$ $\qquad$ $XY < AB$

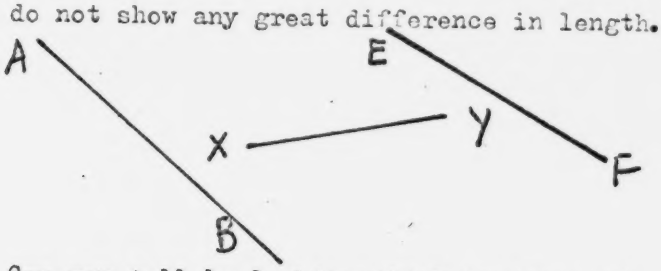
Q. Now, if AB is seven unifix (redraw AB and XY); lets measure XY in raisins. How many raisins do you think it will measure? (Mary measures XY as 16 raisins.)

Q. How does it happen that the longer line AB is only 7 unifix while the shorter line is 16 raisins?

DIS.: (You should get many valid answers to this, without pushing; however, listen to what is being said so that you will

understand their ways and means of measuring.
It may be that something that sounds to you incorrect, is really an accurate answer, the child is just stating it in a different way or perhaps a different, more interesting and creative point of view.

PROB. 7a: If you have some lines to measure AB, XY, EF, draw these three line at variance to each other, and do not show any great difference in length.



DIS.: Q. Can you tell by looking which is longest? What do you wish to use to measure? Only one rule, it has to be in units; you can't use something like string, because I have to write down the answer. If children choose to use e.g., raisins to measure all three lines, ask them why they did this, and why they did not use three different units. If they do use three differing units, one for each line, explore the problem involved. Which is longest? How can you tell? Asking other children to agree or disagree with any statements made is good. Obviously the point in this PROB. is that within a given circumstance any cogent and valid comparison has to be made against the same norm.

Repeat here: (and if needed again in the DIS.)

AB > EF > XY or AB > XY < EF

DIS: The discussion of the above question may involve more than just the above. It may lead into repeating another circumstance, allowing a child to prove out his reasoning or a child offering another set of circumstances which have to be proven out. Do not jump to hastily from one PROB. to another; be sure each has been throughly discussed. Conveniently, games and shelf exercises will allow the "sense" of a PROB. to settle in.

THEORY: Bar charts, charts and datograms - most of the work that the children will be doing will be in these areas. There will be a few elementary graphs. Graphs are distinguished by the use of two <u>different</u> types (e.g., time against distance) of quantitative measurement: one on the horizontal axis and one on the vertical axis.

In scientific endeavor, one is involved in gathering data, hypothesizing, experimenting, organizing results and then repeating the same line of action from another point of view. The end result is a cumbersome verbiage of statements, calculations and figures. Charting presents a very efficient way of representing and visualizing data. Furthermore, many statistics can be compared in juxtaposition. Relationships that are revealed in a chart are often undetected if confined to a purely verbal analysis. To scientific inquiry, charts and graphs are a short-hand code for organizing information. For children charts are a fun way of learning. Charts can communicate information to a child. A child wants to know and to understand but many times he does not "see it". That is, his mind is unable to interrelate a given set of ideas; or he does not understand that there is any importance attached to ideas "a", "b", "c", since verbally they do not seem to be related. A chart enables the child to visualize or "see" in such a way that he can better benefit from the sense of the thing that he is learning.

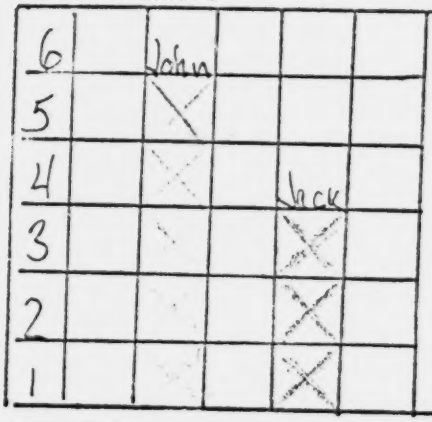
The children must first learn how to make a chart. The preliminary effort is to stress the significance of the horizontal axis. (The vertical axis will fall in naturally.) After this the focus is on how to "read" a chart and what they can "tell" you. These efforts will be stressed in PROBlems 6 and 7. Thereafter, discussions of various charts that the children have made will further illuminate their significance.

(Note: since PROBlem 2 the curriculum has steadily been leading up to the actual PROBlem of making a chart.)

Encourage individual children to interpret their charts in writing which can be on or attached to the chart. To further serve the purpose, children in groups can be allowed to exchange charts, read the information given, and see if they can think of questions that are not answered or things that they would

ARITHMETRY, Charts (con't)

like to know.



Race and Measure Scores
for May 7, 1970
These show the number of times that John and Jack scored 4 on the board. We did not count any other scores.

A group of children examining the above chart want the answers to the questions below given.

How many times altogether were the cars run?
How many more times did John win than Jack?
How many less wins did Jack have than John?
What color was Jack's car? What color was John's car?
Do you think the scores would be the same if they traded cars?
Try it.
Write down what your vertical line (axis) shows.

Naturally, in the prelinimary stages of charting, very simplified techniques should be used.....as was seen in the sticks placed in the clay base (PROB. 2). Examples of elementary charts would show an immediate transfer e.g., the actual string lengths are simply taped to a paper along a horizontal axis. A second stage represents a chart that "grew" e.g., a chain of paper clips of unifix beads which can then be used as such or laid directly down on paper and traced around. Third, a symbolic chart, this will have a one to one correspondence but the notations on the chart (whether plain"bar" or"picture bar") only represent the measure, they are not an exact replica of the thing used. (see picture, next page). The datagram and chart work done with GAMES and scorecards are simplified bar charts which will make interpretations of the more "abstract" work easier to

THEORY, Charts (con't)

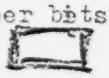
understand. (coloring in the leaves)

		Number of leaves on five rose bush stems plucked at the base from the same rose bush							
stem 1									7
stem 2									7
stem 3									5
stem 4									5
stem 5									3

(The above example can be used as SHELF MATERIAL chart work)

The fourth stage is representation by scaling which overlaps somewhat with the third stage.

Example: using pasted-on colored paper bits

Number of big steps (B S)  = 5 B S

B S from school room to lunchroom		40BS
B S from school room to office		25 BS
B S from school room to parking lot		30BS

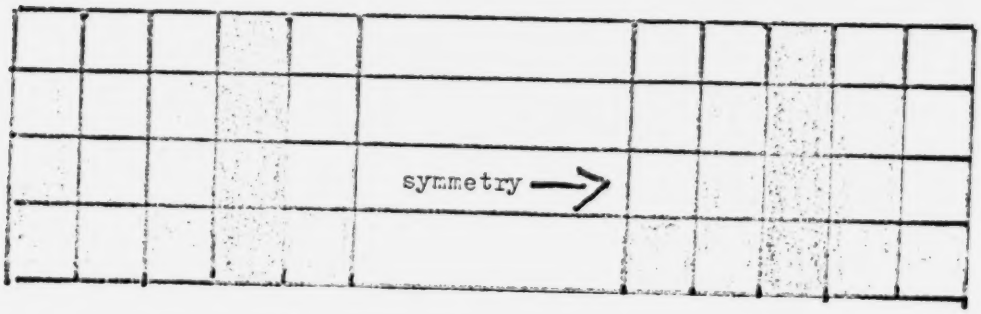
(The above example can be used as SHELF MATERIAL chart work as a variation on "Mapping in Finds" pages 73,74.)

It is suposed that it is better for the child to represent his increments by picturing the actual thing that is being measured or picturing the thing with which he measured. (see above, chart picturing rose-bush leaves). However, it was found that difficulty in drawing and in making exact duplicates of the same increment

THEORY, Charts (con't)

in most cases, imposed more restraint than making the mental transfer i.e. a"colored box"represents one rose leaf.

Since chart making and graphing are skills which follow somewhat regimented rules, the suggestions of the teacher will be needed -- i.e. needed in a way which is more directive than in discussions. She will need to point out different ways of representation. She might also find that a different arrangement might show a significant feature; therefore she would sit with the child trying first to get him to"play" with other arrangements to find if he notices the difference.



(the above showing the peripery of five leaflets of the compound leaf of a hickory tree)

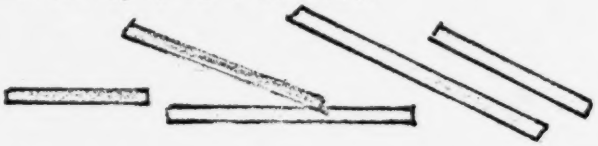
The children will also need manual assistance and help in maintaining repetitive accuracy.

PROB. 8: MAKING A CHART (picture)

Materials: five colors of tape, construction paper.

<u>Do</u> <u>not</u> <u>let</u> <u>children</u> <u>see you do this</u>

On the inside of your hand lay colored tape the length of each finger (Use a different color for each finger). Stick the five tapes randomly on the chalkboard which has been wiped free of dust.



DIS: (Introduce as mystery lines) Have the children ask all kinds af questions about the tape lines.
"Are they the same length?"
"What can you tell about them?"
etc.

PROB. 8 a: Draw a base line on the chalkboard and arrange tapes on line:

DIS. What do the children see now? How does the picture look different?

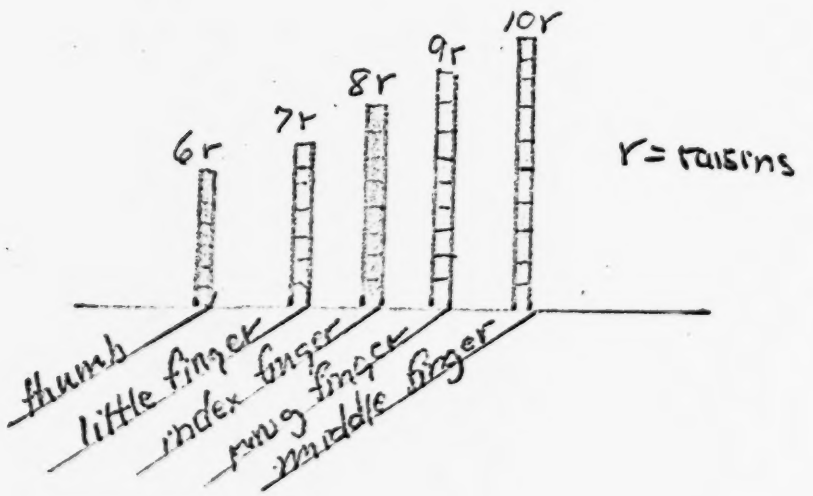
PROB. 8b: Arrange tapes in an order:

DIS. What do the children see now? How does the picture look different?

DIS.: These measure the lengths of something. Just by looking can you tell what <u>thing</u> or things they measure?....(No) Why?....Would you like to know?

(Do not give any information aloud, just write it on the board; someone will know how to read it and once they get the title, they will be able to guess or read the other information.)
What would you like to know? (Try to get the children to complete the labelling for the chart by asking questions...they may want you to put information on the chart that you had not thought of. Do this, if within reason, or if the other children agree that it should be on the "picture" for the sake of knowing what the chart is all about.)

These are the measured lengths of Mary Potter's fingers on her right hand May 16, 1970



PROB. 9: MAKING A CHART

Materials:

1) Have on hand several different kinds of lengths to measure, keeping in mind, these lengths should not be too long.
(Save the notion of scaling for another occasion, so that the most salient features of chart making are "isolated" for this time.)

e.g. the center veins of: elm leaf
maple leaf
pin oak leaf
} or three sizes of leaves from one tree

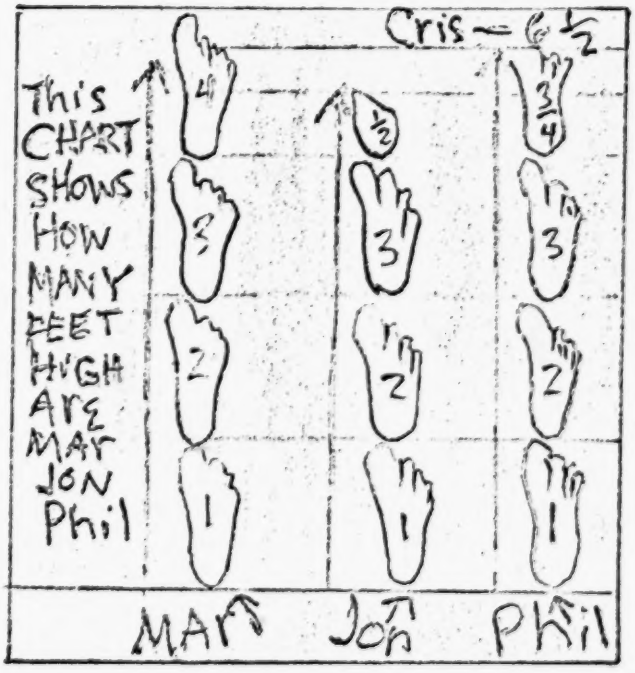
finger lengths
hand, finger, foot, toe
lengths of small animals in room
heights of different plants in room

2. the boxes of"measure stuffs"
3. construction paper
4. various types of pencils and markers

(The children will work in threes or partners, whatever they decide) Remind them first about the note from PROB 2 about the sticks in the claybase.

DIS: (After the charts have been made) In the group, discuss the quality of each chart and determine from the children "What makes a good chart picture". The children will undoubtly talk about charts that are "messy", "scribly" and "hanging in air" as well as those that don't mean anything to anyone but the person who made it. Encourage children to make charts from an artistic, interesting point of view; provide materials (at all times) that will stimulate an artistic, creative approach...this will make charting a "fun project" as well as a learning process.

e.g. (from a creative child's point of view)



Some materials to provide:

Art papers
Gummed backed paper
Different types of stickers to use as increments
Colored pencils
Colored tape
Crayons
Yarn
Cut cardboard figure increments to trace around

PROB.10: DEVELOPING A STANDARD

Select two leaders for two tribes. The leaders should then choose up their tribes e.g. Phil's tribe and Mich's tribe. Take aside e.g., Phil's tribe and decide with them a common standard e.g., unifex (this is kept secret from Mich's tribe). Then draw lines of the same length e.g., eight unifex , each line on a separate sheet, enough for all members of Mich's tribe. Phil's tribe then distributes papers to all members of Mich's tribe and tells them that they are to measure their lines. Mich's tribe will undoubtedly measure their lines individually each using different units. Having done this Phil's tribe puts them to the test:

Tribe P: "How long , Mar?"

Tribe M: Mar says, "16 raisins"

Tribe P: "No, not by our standard"

Tribe P: "How long, Jac?"

Tribe M: Jac, "ten paper clips"

Tribe P: "No, not by our standard"

Tribe P: "How long, Fin?"

Tribe M: Fin, "eight unifex"

Tribe P: (Keeps this in mind... that Fin got it; however, no indication is given until all children in tribe M have been asked "how long".) At the end, all children who by chance had measured with unifex are asked by tribe P to come over to their side. This can be done several times. The "exclusiveness " of tribe P was established in the beginning; without saying anything, the children get the idea that they would like to be a member in good standing with tribe P; they assume there exists a specific way of gaining entrance but only those that have joined tribe P know the answer. Once the remaining children in tribe M come to the conclusion that the game is unfair because they know for sure that the only way to gain entrance is to know the "standard" and tribe P will not tell them... then cut the game but do not assuage their annoyance, this is the way to heighten the concept which you are trying to put across.

DIS.: What was the game about?
Why did only some children get to join team P.?
Do you think tribe P has a right to accept into the tribe only those people who use their standard? Why?
Do you think it is fair to have a standard? Why?
Is a standard useful?
Do you think if someone has a standard, that he should explain what it is and how it works to everybody else?
(Keep asking questions, depending on what ideas and questions the children raise, until the subject is exhausted.)

PROB. 11: (should be done the following day, or soon after)
Divide children into two countries as in PROB.10, by choosing up sides. Draw on chalkboard a similar representation of what they will be given, presenting the situation problem and how they are to try and solve it.

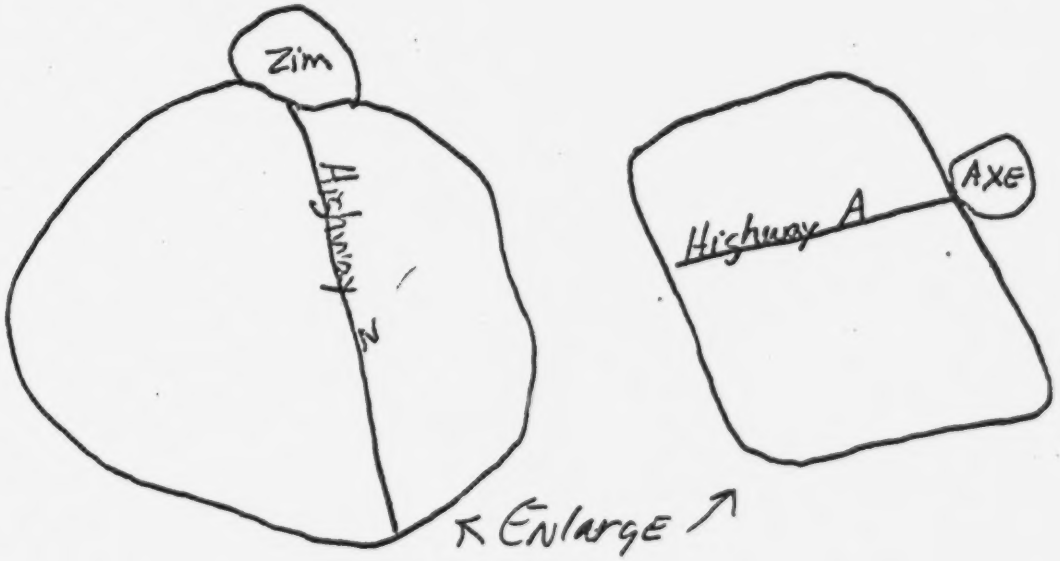
Each child in each country will be given a silver wrapped candy; this is symbolic of their nations wealth and riches. If their nation is the one that is invaded, they must give their wealth and riches to the invaders.

Each "nation" will be given a map of their country. Each country has an express highway, marked on the map. All citizens live in a town, which is marked on the map, and which is located at the end of the highway. The citizens of country "Zim" and country "Axe" both decide to invade the other at the same time, it just so happens that there are <u>no tactical maneuvers</u> involved. The conquerors

will simply be the nation who has the shortest highway to travel. Now we only want to determine which nation has the shortest highway, that is all; then we will know who are the conquerors and who will then get the riches of the other nation. Ask if there are questions?

Each child is given his candy to save. Each nation is given its map; all children should see both maps but not the unit that will be used. Each nation is given the map of its country marked with the town and the highway. Each nation is given the unit of measure that they are to use e.g., the nation with the shortest highway is given the shortest unit; the nation with the longest highway will be given the longest unit. Have the maps and units prepared so that you are sure that the shortest highway measures e.g., twenty-one unifex; but the longest highway measures only e.g., twelve bobbypins.

Hopefully there will ensue a confusion, bickering and refusal to give away candy since the children having seen the maps, have made a previous visual judgment. Then when the unit figures are given and the "short" highway attempts to take the candy from the "long" highway, they will object and call for some type of remeasure. At this point call for a discussion.



DIS.: Why the argument?

What could be done to solve the argument?

What shall we use?

Do all agree?

What if one nation attempts to say that they have less units in their highway than they <u>really have</u>...just because they want to be the conquerors?

(note: In this connection it would be appropriate to read selections from any of the following books which give accounts of how and why standard measures developed in tribes and among nations...their problems, arguments etc.

Benedick. <u>How Much How Many?</u>

Adler. <u>Giant Bolden Book of Mathematics.</u>

Epstein. <u>The First Book of Measurement</u>. Chapters 1 and 2.

Hogben. <u>The Wonderful World of Mathematics</u> (paragraph selections)

Rugg. <u>Communities of Men.</u> pp. 98-99.

APPENDIX I:

Games and charts

(Note: all game boards can be cut from light weight poster board, drawn with magic markers and covered with clear contact paper or sprayed with a plastic spray. For storage purposes, you will find it convenient to cut a game board in half and seam it loosely on the back with two inch tape. This will allow the board to be folded.

You will need a good supply of at least three colors of unifix beads.)

GUESS AND MEASURE (visual discrimination)

two to four players

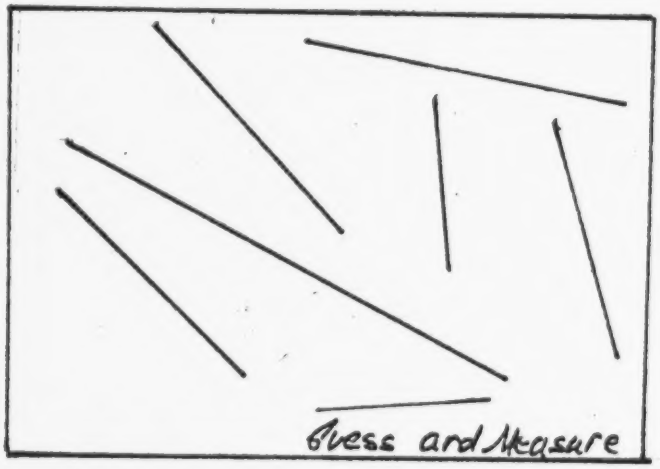
Materials:

1. game board (see below)
2. a box of string lengths the same as the lengths on the game board. For any length on the board, there should be two or three strings of that length to match. This is done so that the children do not play by the process of elimination.

Game:

1. A child chooses a string. He must guess which line it matches before placing it down on the board. If it matches, he keeps the string; if not, he must return the string to the box.
2. The winner is the child with the most strings.
3. Variation: the winner is the child who has the longest length of string when he places them end to end on the floor.

Board, stage I



Board, stage II
(on reverse side)

POT OF SILVER (purpose: determining the shortest route...which in this case is not always a straight line.)

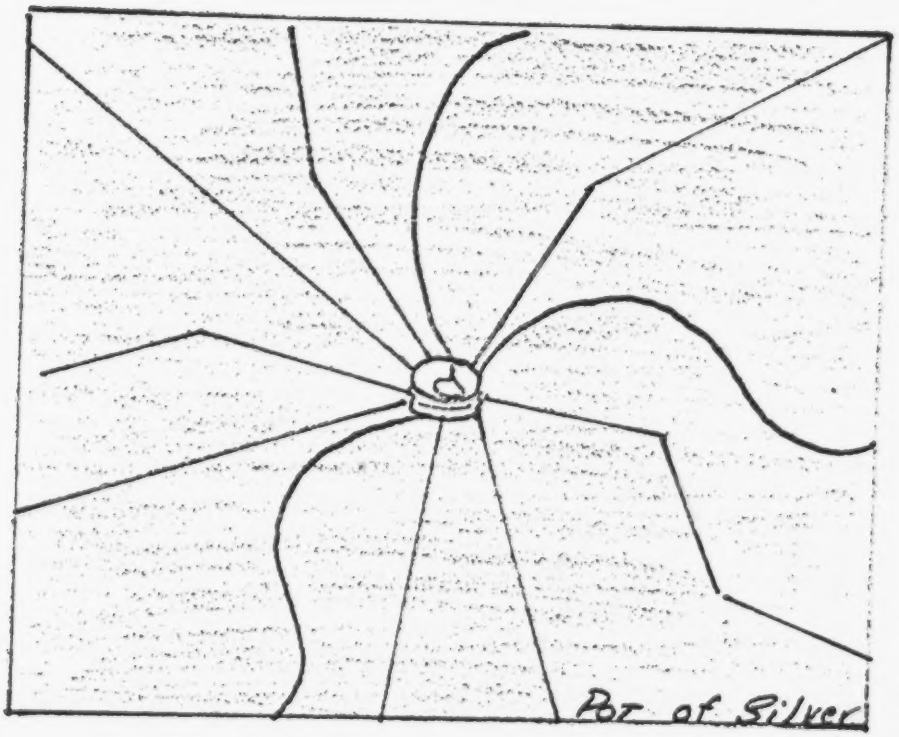
two players

Materials:

1. board
2. pot...with a silver wrapped "Hershey Kiss"
3. units for measure (children playing can decide on, but obviously both children must use same)

Game:

1. players determine which line they will use as a route
2. player one puts down one unit
3. player two puts down one unit
4. etc.
5. the player who reaches the "pot" first gets the candy bit.
6. another candy is then placed in pot...each player must choose a different route i.e. he cannot at the same sitting ever use the same route twice.

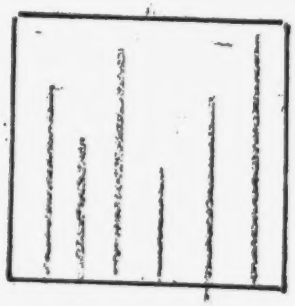


MEASURE / MATCH LOTTO (tactile discrimination)

two to four players

bag with strips of wood of lengths that match the lengths on the lotto cards.

lotto cards (4) approx. 11"x11" with about six vertical lines on each.



Game: 1. child chooses a lotto card.

2. play 1, child feels in bag, without looking, for a wood length which matches one on his card. If he pulls one that does not match , he must return it to bag (he gets no more trys until next "round".

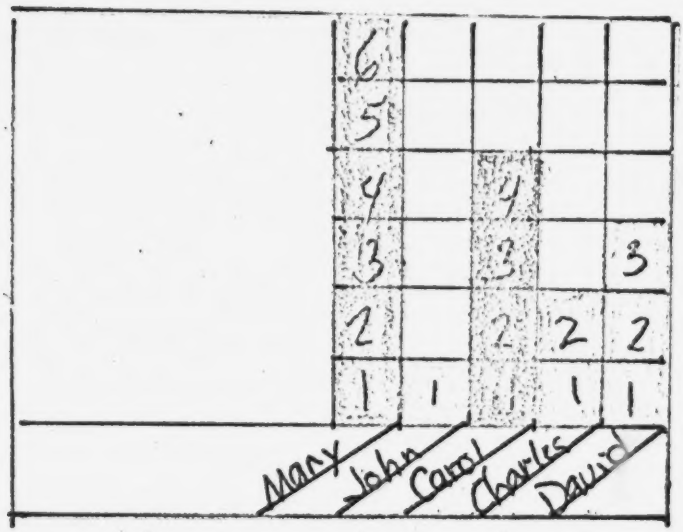
3. child who completes his card first is the winner.

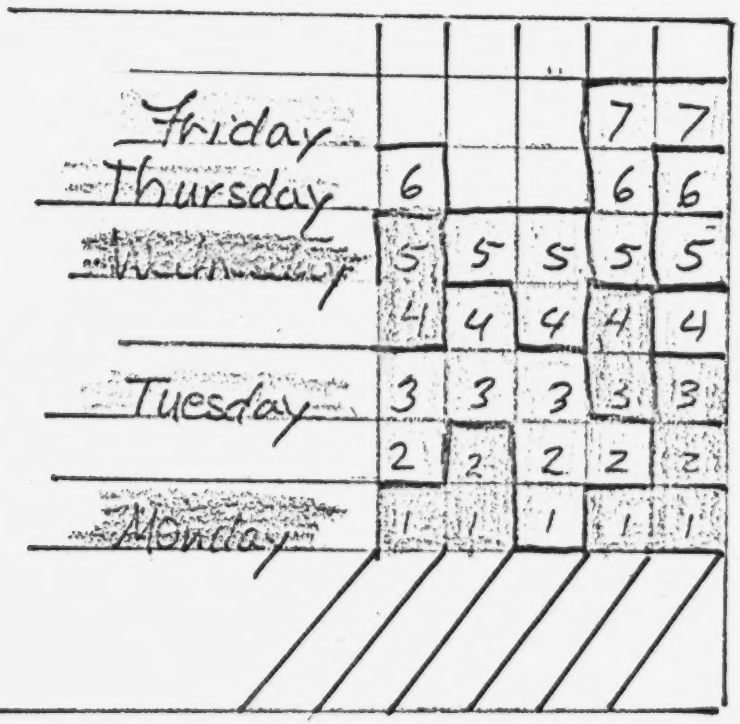
variation: as children get better, you can tighten up the competitive angle by allowing a child to "hold" the game as long as he keeps choosing a length which he can use.

Scoring: done as chart, will hold interest in playing the game which then has the semblance of a tournament. Chart may be "in progress" for one or two weeks or kept up indefinitely, adding to it whenever the children play a game. (Before school?)

MEASURE/MATCH LOTTO (con't)

Scoreboard bar charts: (precede any chart work with PROBS. 6 and 7 Charts and the discussions)





GUESS HOW MANY UNIFIX AND MATCH

two or more players

one game caller and score keeper (one child)

Materials

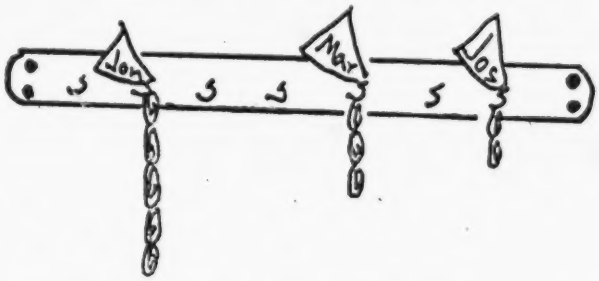
1. game board
2. hanging paper clip graph apparatus (can be use for other graphs)
3. paper clips
4. unifix beads (two cm interlocking cubes made of polyethylene) see "materials"

Game

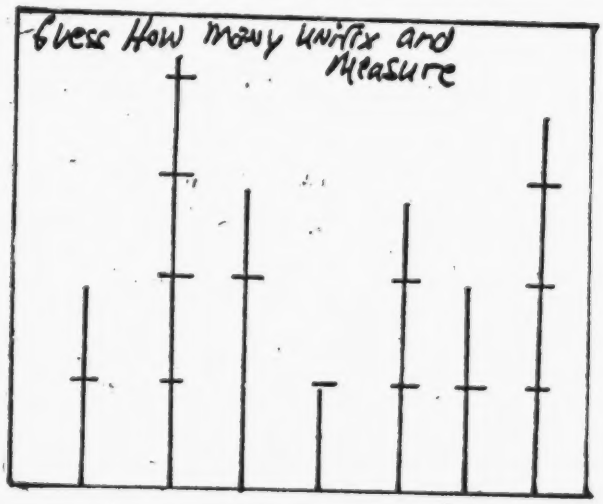
1. Game caller points to a line on the board and asks player # 1 how many unifix it will take to exactly measure the line. Player # 1 says "five" and then lays down unifix---if he is correct the score keeper puts up one paper clip on player's "hook"---if wrong he does not get a point.
2. Game caller repeats with player#2(pointing to another line, unless the first player failed to score on the measurement of his line, in which case the same line is used)

(Note: the score board of hanging paperclips forms an automatic graph.)

Length of wood with $\frac{1}{2}$" hooks screwed into wood at intervals, can be tacked to wall at child's height.



Board: The vertical lines are cross marked at points of five unifix to get the idea of smaller units composing a longer unit (but DO NOT tell children that they are marked in this way, let them discover. The marks on the board are enough of a hint...other than that it should become a point of understanding relationships.)

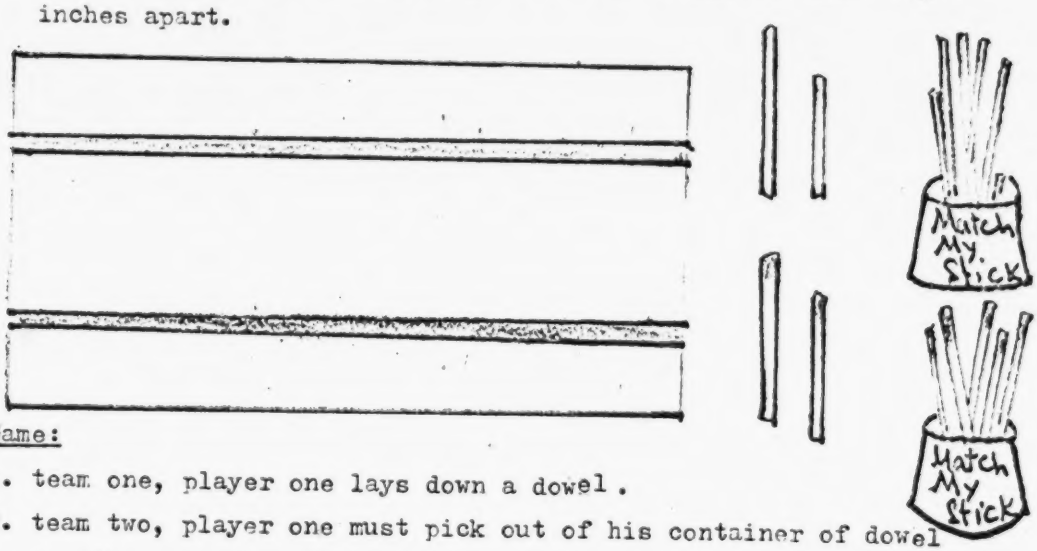


MATCH MY STICK AND MEASURE (purpose: perception of length)

two teams (or two players) and scorekeeper

Materials:

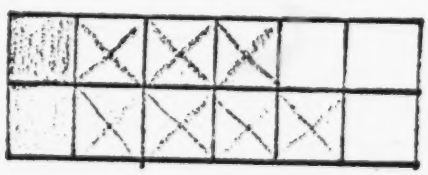
1. two sets of dowel or wood lengths the size of the track approx. ½" (one set consists of two each of 1" to 8" length, the other set is identical; each set is "tipped" in its color, i.e. an orange set and a blue set)
2. Board; thirty-six inches long, with two tracks at least eight inches apart.



Game:

1. team one, player one lays down a dowel.
2. team two, player one must pick out of his container of dowel lengths, one that is the exact same length as that of team one, without matching first....having put on board, if it is not the same, he must put back in container...however, he now lays down another dowel length which team one, player two must guess.
3. Team one, player two picks the dowel he thinks will match... if it does match, he still gets his turn to lay another stick down for team two to guess for their track line.
4. Winning team is the one who gets to "STOP" line exactly, i.e., if they go over, that team automatically looses.

scorecard: since this is a short game, each X stands for one game



GO AND TAKE (purpose: practice in using number as calculators for length and symbolically representative of length)

two or three players.

Materials:

1. game board; three tracks, approximately 45 increments each. Draw tracks on board using the unifix beads so that the size matches and so that the indentations mark the end of each unifix. Each track is a different color which matches the color of the players supply of unifix. The tracks are numbered consecutively from one to forty-five, which is an indirect reference notation of total sums and remainders. Insert a "stop" sign for every fifteen spaces so that short games can be played.

2. deck of cards; the deck can have any type of mathematical calculation providing that the children know how to do the opperation. One "vanquished" card is inserted (for the sake of the "game"). The player who takes this card has two choices: 1) he leaves or 2) he stays, but he must remove all of his unifix and begin again with the odds against him.

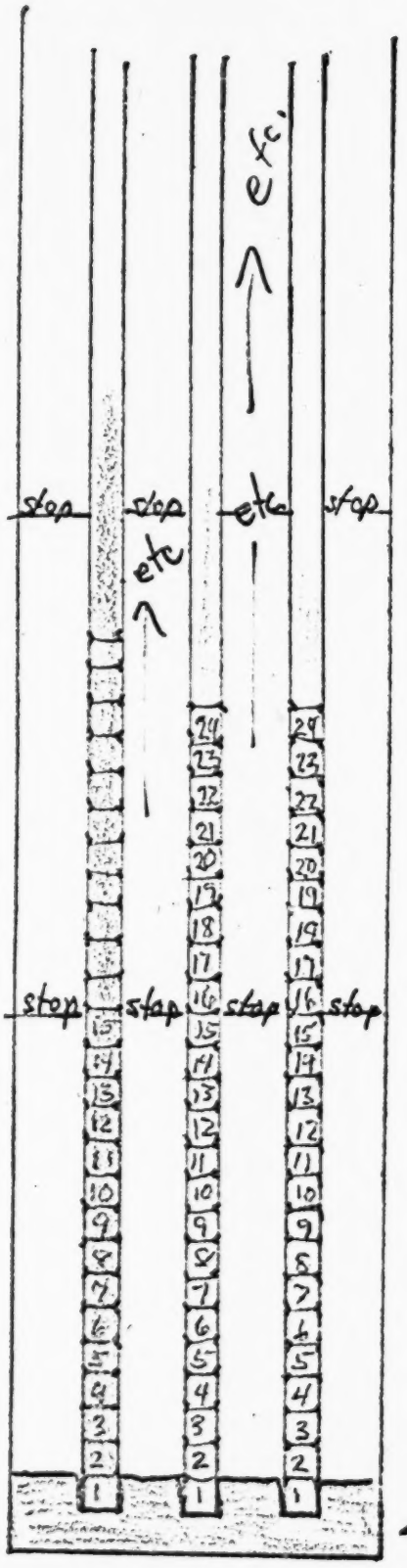
3. a supply of unifix for each player. Each is the color of a track.

Game:

1. The first player takes a card which says e.g. "Go 2+5; he then takes 2+5 (or 7) unifix and places them on the board ...etc. (notice that the board notation, in linear math, places him at 7, therefore having seven; on the next play he may get "Go 4+1", the original 7 plus 5 puts him at 12) (SEE next page for diagrams)

GC AND TAKE (con't)

example of card deck



60
7

60
2+4

60
2+2+1

60
2 and
60 Again

60
2-2

60
2+3-1

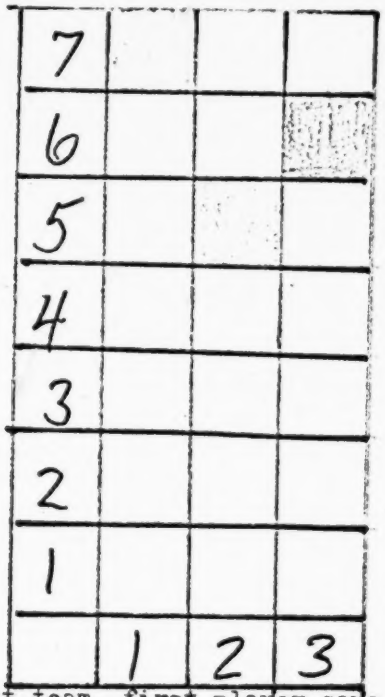
60
8-7 and
60 Again

Vanquished!

← elevated wooden strip - to hold the end

GAMES: Graphs three or more teams; 1, 2, and 3

1. A chart form is drawn on the board:



Game: first team, first player says e.g. "go over one and up seven".

second team, first player, "go over two and up five".

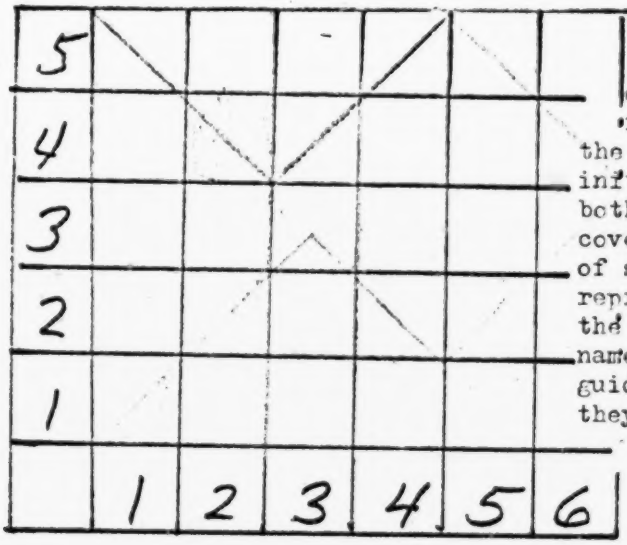
third team, first player, "go over three and up six".

Continue in rotation...the object is whose team can color in their entire vertical column first...any player who repeats something already filled in or gives an incorrect column looses his turn. (The vertical "color ins" do not go in numerical order, that is too easy.)

(The teacher at first will have to be the one who colors the place; later, a child who understands well how it works can do.)

GAMES: Graphs, two teams

2. A chart (see below) is drawn on the board.



It makes no difference how or in which direction the teacher draws the initial lines; but both team lines must cover the same amount of squares. The lines represent only a guide; the children are to name or interpret the guide by saying where they are on the graph.

This time the lines have been drawn but boxes have not been colored. One line (starting at 1) is team one, the line starting at five is team two, The object is to color in the boxes in sequence, starting at the left. The winner is the team which gets to the right side first. An incorrect statement is not counted, the team looses its tern.

The teacher will at first be the one who colors in the squares, later a child can do.

Team one, player one, "color up one and over one".

Team two, player one, "color up five over one".

Team one, player two, "color up two over two"

Team two, player two, "color up four over two"

Team one, player three, " color up three over three".

continue in rotation....

SHOOT AND CHART (Instamatic chart notation as well as getting a tactile sense of length associated with numerical quanitity.)

one or more players

Materials:

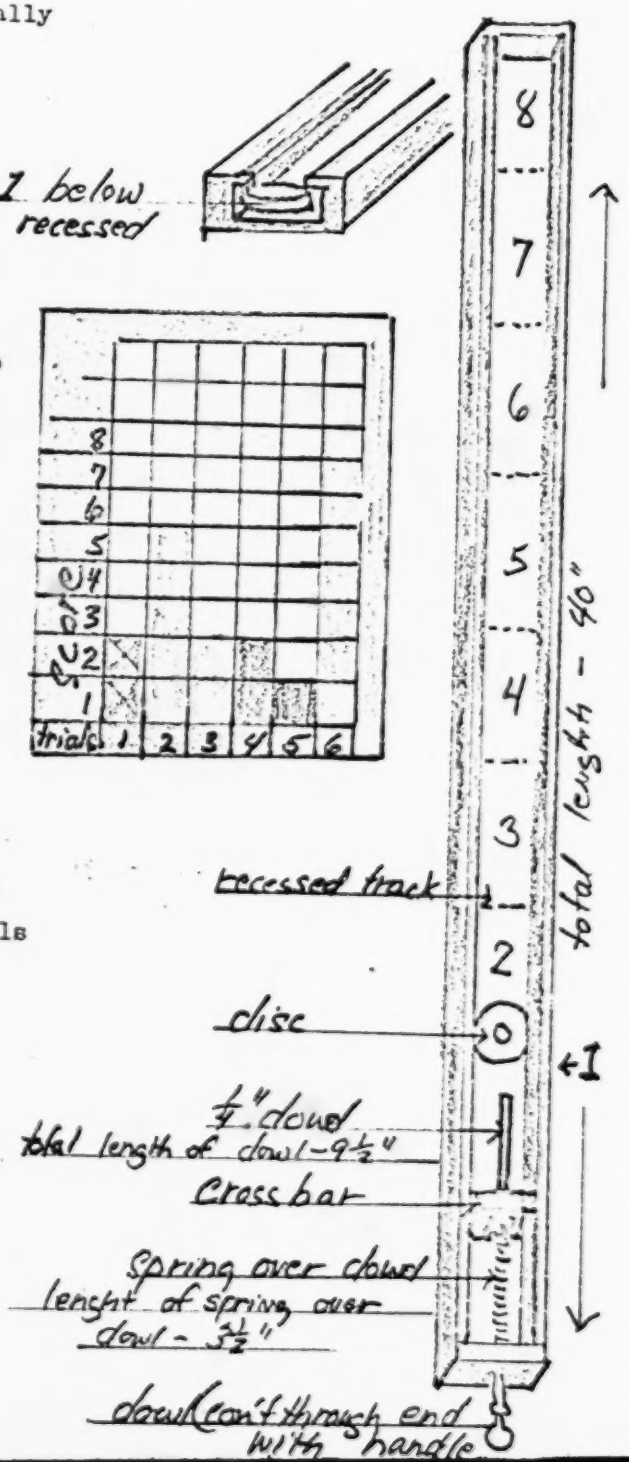
1. a wooden "pin-ball" track, approximately four feet long. The track has a disc which just fits the size of the track. The track is numerically scored, consecutively.)
2. score paper (use ¼" squared graph paper)

cross section of I below showing disc in recessed groove

Game:

1. child pulls spring stick and shoots disc; if disc goes into box 5, then he colors up five vertical squares over "trial one" on graph paper. (Here he is getting an indirect suggestive percent of scaling for the sake of a chart.)

This spring lever apparatus has some built in mechanical properties of motion which should be included in chart results e.g., chart eight trials done on level...chart eight trials done on slight incline...try to maintain a constant in the "shoot force" by marking the length to pull out the lever for each trial (see diagram). There will be other ways in which to use for obtaining other comparative results; these will become apparent upon using.



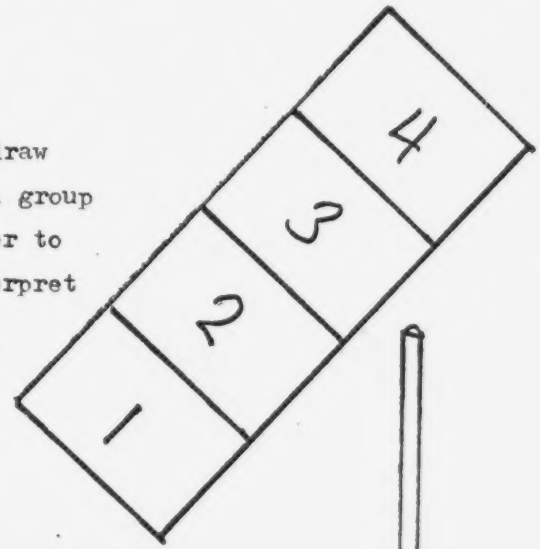
SHOOT AND CHART (con't)

Variation 1: contrive a similar numbered track on floor using instead a child size shuffleboard, disc and pusher

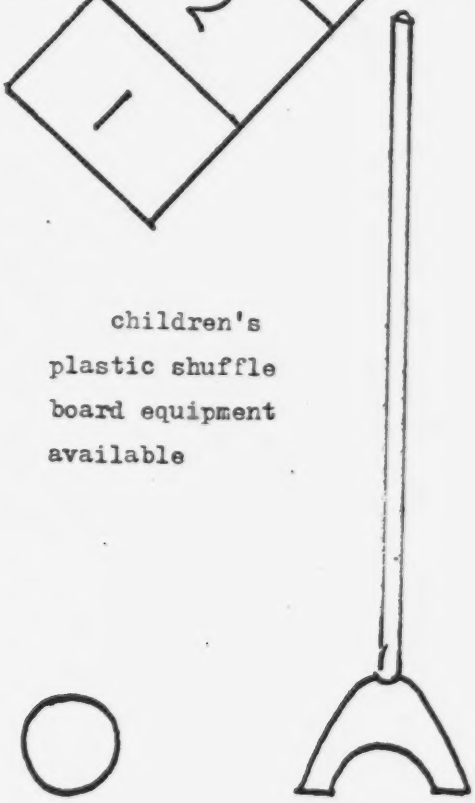
Variation 2: same as var. 1 with two sides

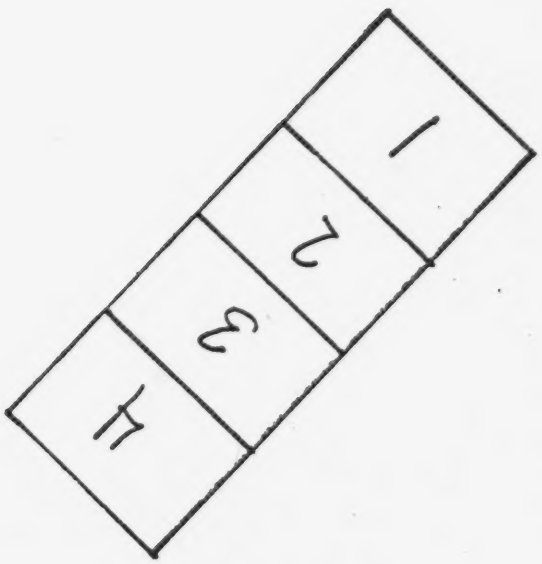
(Purpose of variations is for tactile, muscular memory in perception of length.)

use washable magic marker to draw the "board" on floor (A small group effort should allow the teacher to see how well the children interpret measuring in terms of application.)
use same chart or variation scoring technique.



children's plastic shuffle board equipment available





RACE AND MEASURE (purpose: using the operation of addition of numbers as an abstract concept of length; this is totally abstract whereas a chart has been a concrete representation of length and measure)

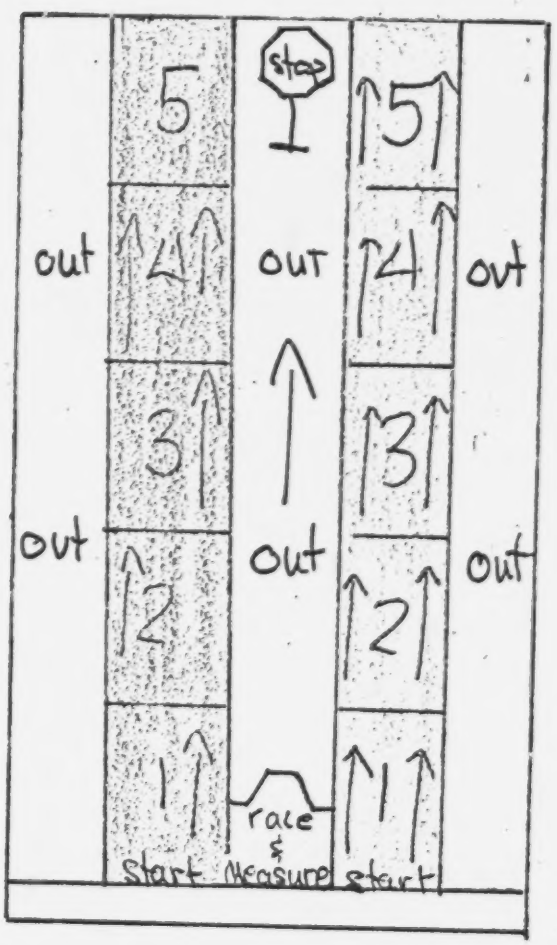
two players

Materials:

1. game board, with two numbered race tracks being the same color as the car to be raced.
2. two small "matchbox" type cars
3. score cards with magic markers the color of the two cars.

Game:

1. player one puts car at start mark and gives car a shove... if he goes over the track (end or side) he gets no score.... otherwise he gets score the number of the box in which his car stops.



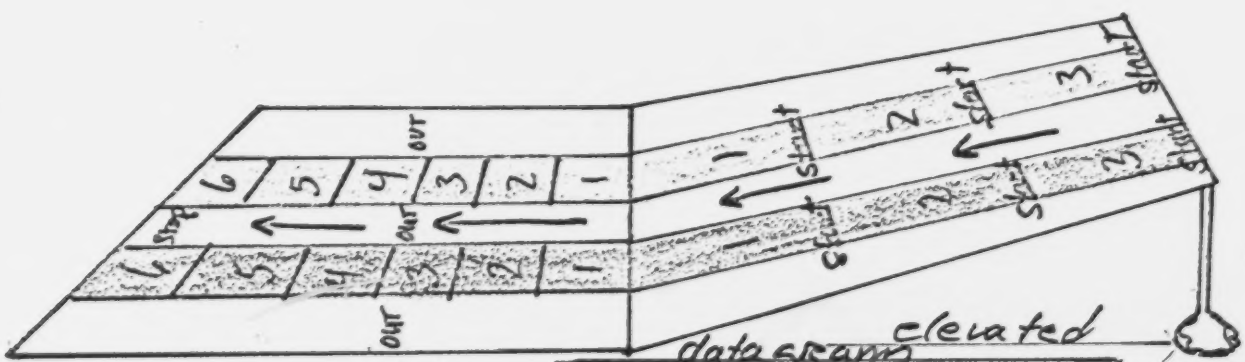
	1		4
	2		3
	1		2
	3		3
total	7	1	2

RACE AND MEASURE (con't)

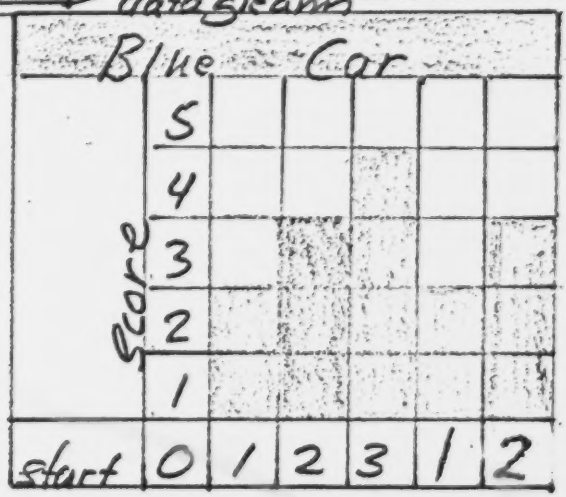
Variation 1. The variation consists in having a reversed numerical sequence track (rather than a "start" line) which can be hinged (taped) to the original board. The hinged part can then be elevated slightly for the purpose of obtaining a more complex type of datagram. Instead of a score sheet which tells the comparative scores of each car at a glance, in variation 1., each child would keep his own datagram and then compare his results with those of his partner.

Game: 1. elevate the part of the board marked "1" about an inch and a half.

2. e.g., according to the datagram below, the blue car starts in place one on board 1; he lets his car just roll (no pushing). The blue car, as the datagram show, rolls to place two on board 2. The second time, the blue car is put in place two on board 1, the car rolls to place three on board 2 etc.



datagram



GAME: THE STANDARD (a group effort)

(Note: the following plan was that which was devised by the children under whose lead this curriculum was outlined. The the three items listed below may be substituted for something similar.)

1. The children were each given an unassembled wooden car; they took them home, assembled them and painted them to their own liking. The purpose was simply a gimmick to interest each child in what was to take place. This may be substituted, having each child bring to school his own premade model car.
2. The teacher devised a premeditated plan for the "standard" which was in base four. The units of measure were made of strips of wood. The longest (approximately 56" long) was named a "Find". The next longest (approximately 14") was named by the children, a "Kaiser". The next, named a "dinky", was approximately $3\frac{1}{2}$" long. The shortest, named a "medor" was approximately three-forths inches long.
   4 Kaisers = 1 Find
   4 dinkies = 1 Kaiser
   4 medors = 1 dinky
   The width of the wood strips was also equal to one medor. There were, and should be, many of each unit so that they can be layed end to end in measuring. This may be substituted with any base measure or simply using a linear system already in use, i.e. inches, feet, and yard or the metric system. The only requisite is that there are individual pieces for each unit and that each unit is available in quantity.
3. The names "Find", "Kaiser", "dinky" and "medor" were given by this particular class of children. It is recommended that any group of children give their own names; they will be better remembered.

First day: The teacher will explain the game as a car race, each time only two children will race. Each will race for three times and then the score will be added up. Then players will switch places. She then shows them the new standard measure which everyone will use (on the first day "Finds" and "Kaisers" only are used).

GAME: THE STANDARD (con't)

Materials:

1. many Finds
2. many Kaisers
3. hot rod cars
4. score paper
5. the track taped on the floor (a "start" and a "stop" line must be fixed by tape on the floor.)

Use about a six foot maximum, otherwise the children may not be able to do the mathematics. Cars running diagonally are considered "in" but if they go over the "stop" line the child gets no score. It was found that this confinement kept the game to a more serious activity.

Scorecheets

Bill		
	F	K
	1	1
	1	1
+	1	1
	3	3
total	3	3

Mary		
	F	K
	0	3
	1	2
+	1	1
	3	6
total	3	2

Game:

Name a scorekeeper

Name a referee

Name two racers (competitors)

Each racer appoints his own "measure man" (who measures with the Finds and the Kaisers the distance traveled by his man's car)

The referee: sits over the "stop" line. His business is to 1) keep order 2) see that no foul play takes place at the start or finish point 3) he sees that there is no distortion in the line of measure i.e. that the "measure man" lays Kaisers in a straight line from the point where the car starts to the place where it stops.

The racers: use their own hot rod; alternating turns.

The "measure men": measure the distance for the car of the racer for whom they work. They also call score to the scorekeeper (the score is always verified by the onlookers)

The scorekeeper: keeps score...three runs (an"out" will count as a run with zero for the score) constitutes a game.

On the first day, the measurements are taken only in Finds and in Kaisers (or the longest units).(SEE: SHELF MATERIAL Find, Kaiser worksheets) It will occur to the children or by suggestion that the game is not always fair since the cars sometimes will go farther, but not far enough for the length of

GAME: THE STANDARD (con't)

another Kaiser (the rule being that unless another Kaiser actually fits the gap, it is not counted). There will arise a discussion as to the need for an additional smaller unit of measure.

On the second day the teacher brings in lengths which are smaller... four end to end constitute a Kaiser, these the children named "dinkies". The teacher should explain how they work and how to total scores. (SEE: SHELF MATERIAL, Find, Kaiser, dinky worksheets).

The children become aggressive about making room for another dinky when measuring the distance traveled by the cars. This trickery is easily seen by the opponent and also riles the referee. Therefore, on the third day the teacher brings in a smaller increment to satisfy the need.

On the third day the medor, which is one-sixteenth of a Kaiser and one-forth of a dinky, is brought in. Again the teacher shows children the equalities and how to total scores. (SEE: SHELF MATERIAL; Find, Kaiser, dinky, medor worksheets)
Scoresheet examples:

Phil				
	7	K	d	m
run1	1	0	2	1
run2	1	3	1	2
run3 +	0	3	2	3
	2'	6'	5'	6
total	3	3	2	2

Michael				
	7	K	d	m
run1	1	3	2	1
run2	0	0	0	0
run3 +	1	2	3	3
	2'	5'	5'	4
total	3	2	2	0

GAME: THE STANDARD (con't)

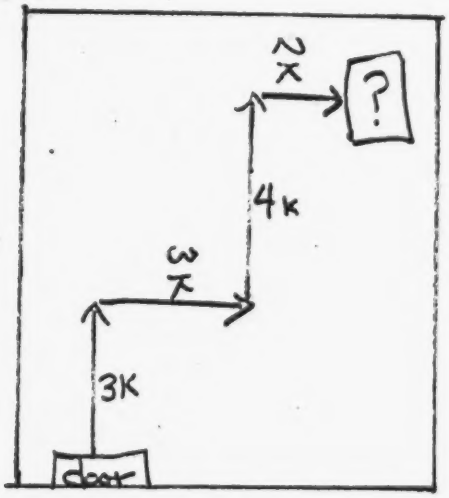
Since learning these equalities and how to keep score is a practiced skill, it will be necessary to make good use of the practice sheets (see: Shelf Material) which should be available in great supply. It probably will be necessary to lengthen the number of days necessary to learning this "standard" sequence. The work sheets should be mimeographed and structured accordingly.

GAME: Mystery Maps (can also be used as "shelf material")

The children are asked to measure the length of their feet placed end to end. It happens that children this age have a foot about six to seven inches long...end to end the approximation is one Kaiser. Once the relationship is understood, explain that it is up to them whether they want to approximate one Kaiser with feet end to end or use the actual standard.

First: The children are given maps and asked to look at the map and try to guess what they will find at the end. (i.e., What thing will be in the "? box"?)

example:



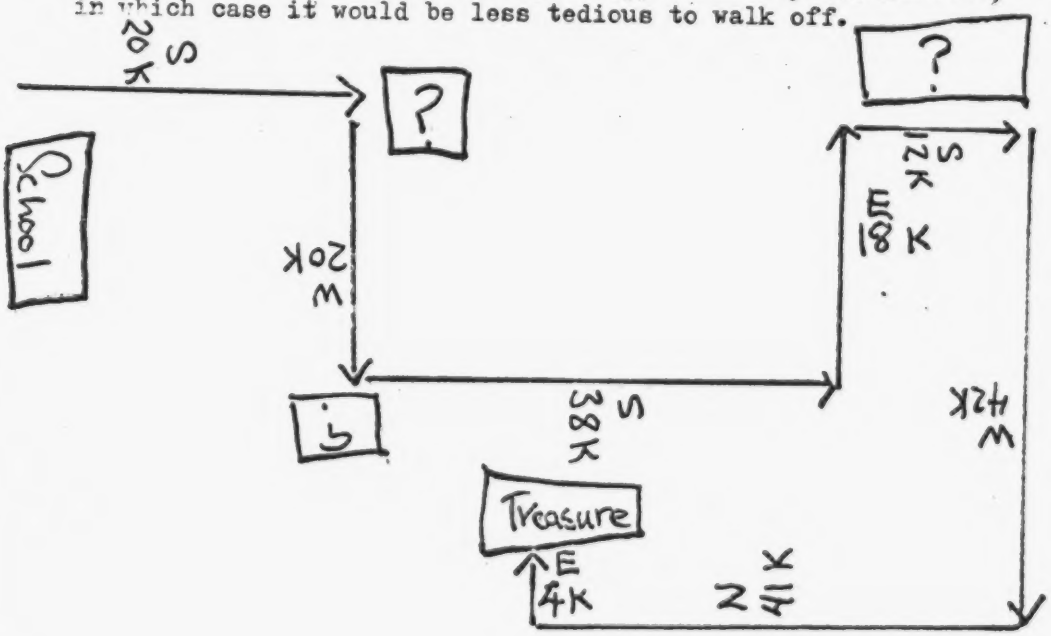
They are to write in "? box" what is there, at the end of the map.

Second: One child walks off a map and draws a diagram on paper as he goes. In this way the map maker knows what should go in the box. He gives his map to another child (one who has not been watching) who trys first to guess by just looking at the map. Then he measures off to find out for sure. He then returns to his map maker to find if he is or was right.

GAME: Mystery Maps (con't)

Third: Mystery Map Treasure Hunt. (Note: if the children do not know how to use a compass already, show them..)
(Only five children should use one map.)

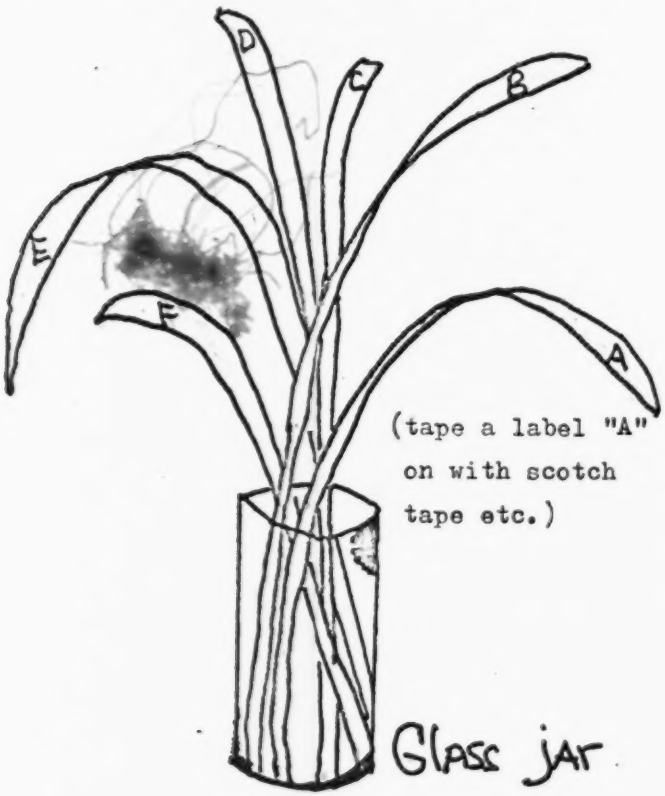
The teacher (with the aid of a child) walks off a large rather involved mystery treasure map for outside. At the end of the route they hide the "treasure", perhaps a bag of gold covered chocolate coins for each child. At each turn in the map there are "?" boxes, at these places the child would be at some significant land mark. He then will place in the box the name of the landmark. (This also represents a clue to the children, i.e., if they have walked off the number of Kaisers on the map and they are not at a "landmark" but are somewhere near the (perhaps.) tennis court, they realize that the tennis court must be the landmark) NOTE: if children can count by "twos" a "comfortable" pace or big step is approximately two Kaisers, in which case it would be less tedious to walk off.



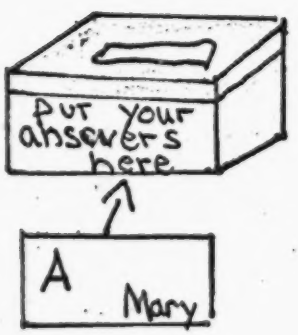
APPENDIX II

Shelf material and graphs

ELEMENTARY MEASURING EXERCISES

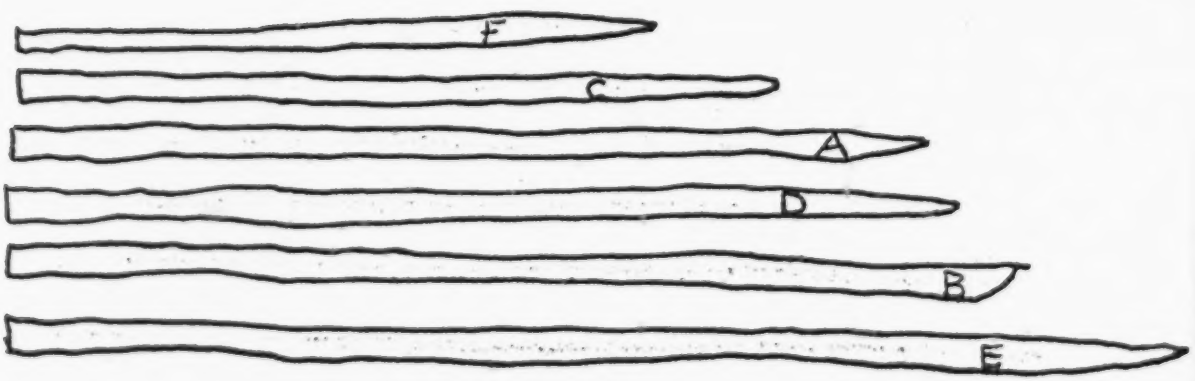


Labelled linear or ensiform leaves in a vase...during the day each child makes an estimate as to which leaf he thinks the longest. At the end of the day the leaves are laid out by the children in an order by length. A written statement can then be made.



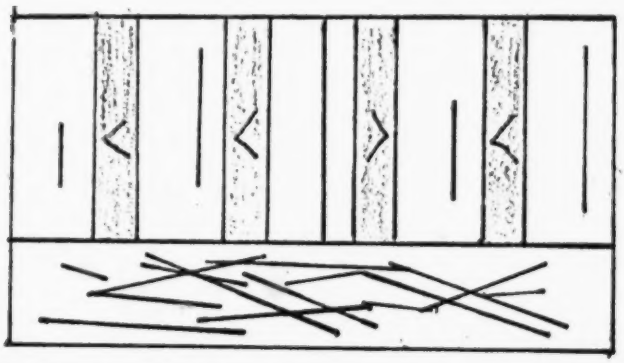
STATEMENT

$F < C < A = D < B < E$



INITIAL DISCRIMINITORY EXERCISES

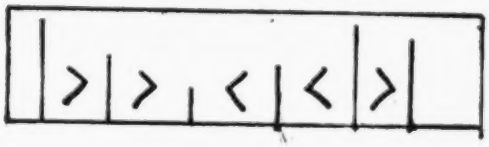
I. Elementary Sorting Tray (introduction of signs > and <)

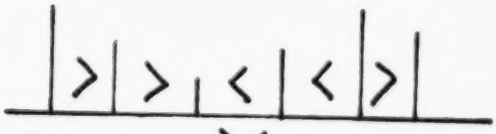


Child matches string or stick lengths to stationary "more than" "less than " series in tray.

II. Play with signs "more than", "less than"

A. Control board and set of > < signs and sticks of same length as control board . Child trys to repeat the same series beneath control board.





B. Box with > < signs..... some pre-tagged sticks; having arranged the sticks and signs in a series (leave it to the child whether he grades them or puts in a symetrical arrangement) he then records his answer on a piece of paper. (after three of four children have done it; they can get together with teacher and compare their answer sheets....a good exercise in unscrambling data and trying to put it in order)

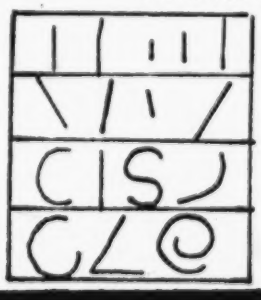
PAPER NOTATION

A<E<F>B<C<H>D<G

Mary

III. More work with > < signs (BEFORE this child must have been introduced to PROBLEM 5 in text

mimeographed paper:



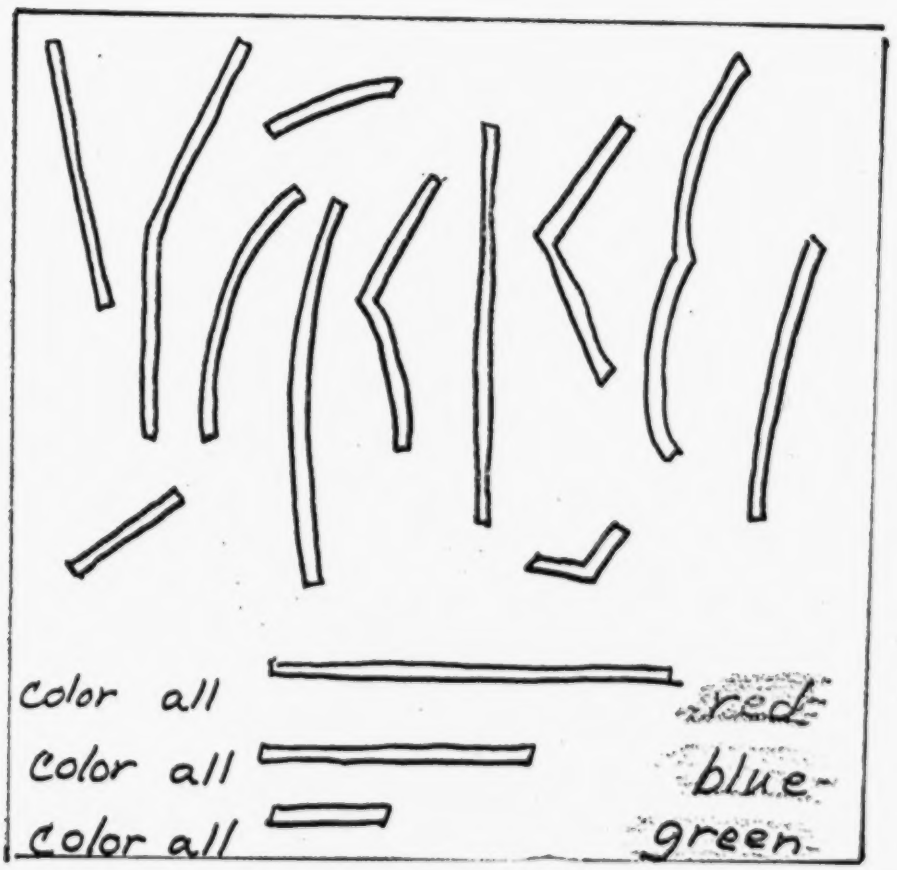
(note: one sheet can be cut into four strips, stages of difficulty) exercise: child writes in > < signs.

ELEMENTARY MEASURING EXERCISE (This exercise should be preceded by PROB. 5 Ways to Measure and the discussion. Readings from the following would be beneficial:

Benedick. How Much How Many

Epstein. The First Book of Measurement

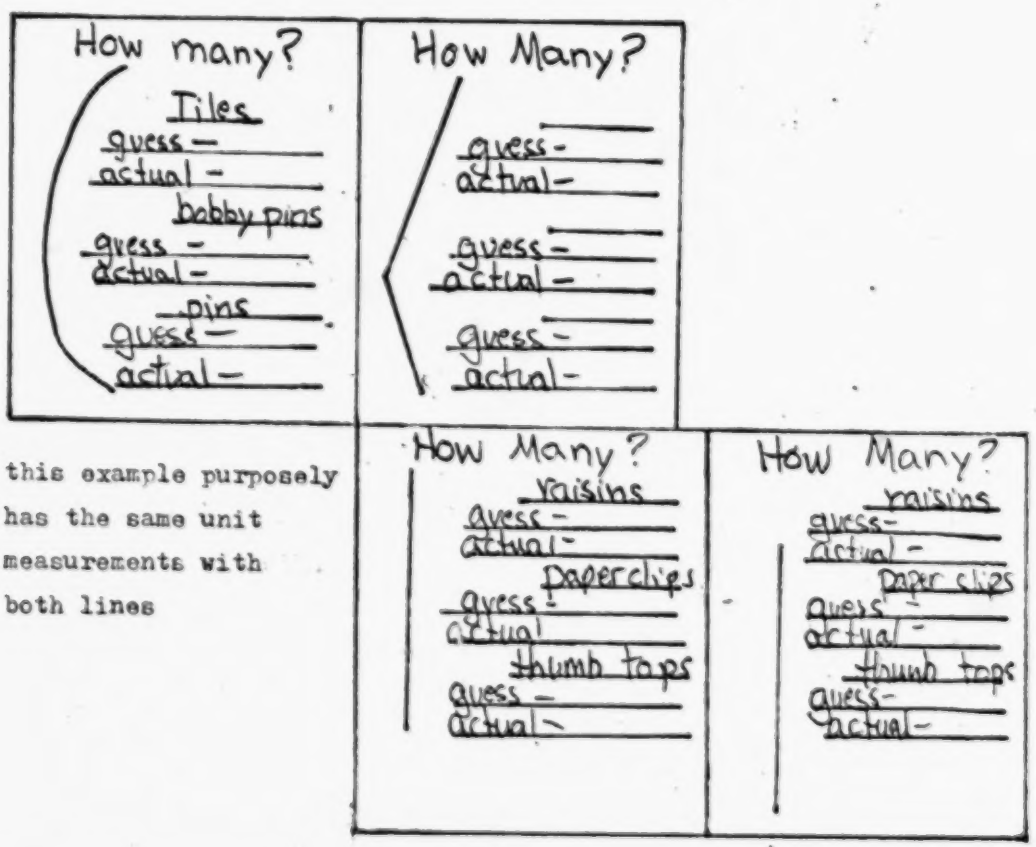
Mimeographed paper:



(the above paper when colored will show a color pattern, starting from left, it will be blue, red, blue, red, blue, red, blue, red, blue; the one at the top and the two at the bottom being green.)

HOW MANY? (purpose: comparative measurements of same line... measurement of straight, curved and angular lines)

In PROB 7 the children named various units which could serve as increments of measure; from this list, containers (boxes) should be made. On the top of each box affix a specimen of the contents along with a name tag with clear contact.paper. In this way the children should have less difficulty reading the new words on the mimeographed worksheets. The work sheet should look something like the diagram below. Note that the two lines on the same paper may appear to be the same length; or to lines that are the same length appear to be different in length. Secondly, the type of unit measure of the second line is left for the child to fill in. Thirdly, The child is always to fill in first his "guess" before measuring for the "actual".



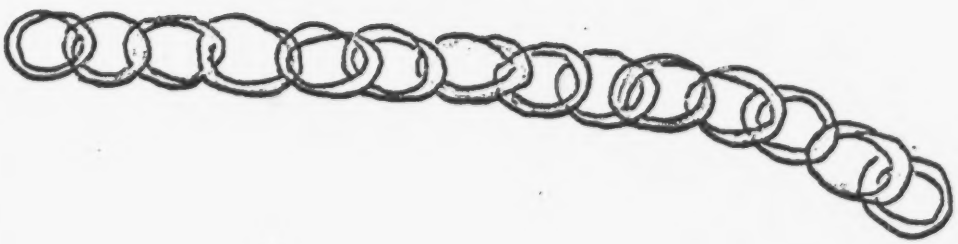
this example purposely has the same unit measurements with both lines

GUMMED LOOPS PROJECT (this was one idea submitted by a child... and it will be found that the children will be thinking up their own games and projects after they get into "measuring")

The project is to measure the length of the room in gummed paper strips that can be made into a length of interlocked loops. Two children begin making the loop chain...after having done about ten (ten because most children can count by tens; therefore if they are able to methodize their guess, ten gives them a unit of estimate); all children make an estimated guess as to the total length. The names of the children are listed with their guess alongside. The project takes several days and different children will be working on at different times. It would be reasonable to allow children to give second and third guesses, or of course retain their original estimate on subsequent days.

Try reading an historical account of the English chain length in measuring acreage:

Benedick, <u>How Much How Many</u>



CAN YOU GUESS? (purpose: making a judgment and applying a skill without being given any suggestion as to how to do or what to use as a medium to find an answer)

See diagram

E.G.:

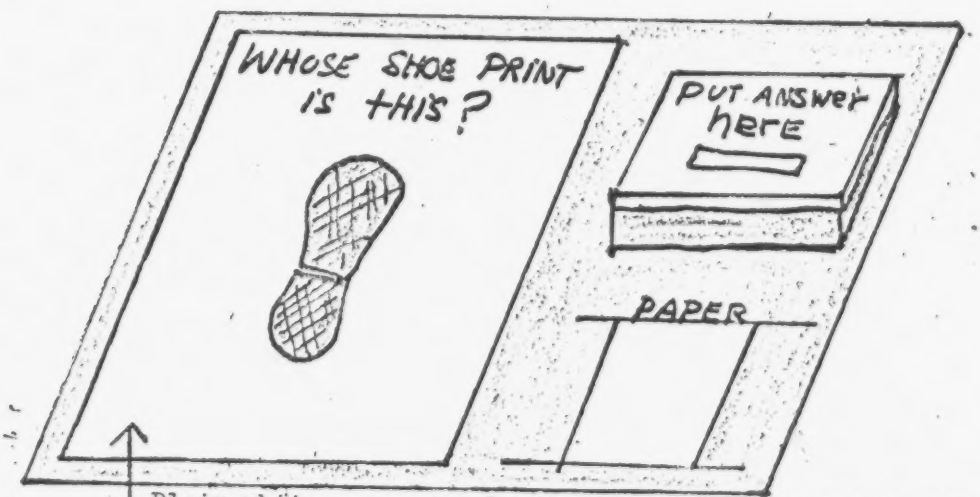
Whose shoe print is this? (available)

This is the length of which animal in the room? (not available)

This is whose hand? (available)

This is the length of which leaf on the sansevieria plant? (not available)

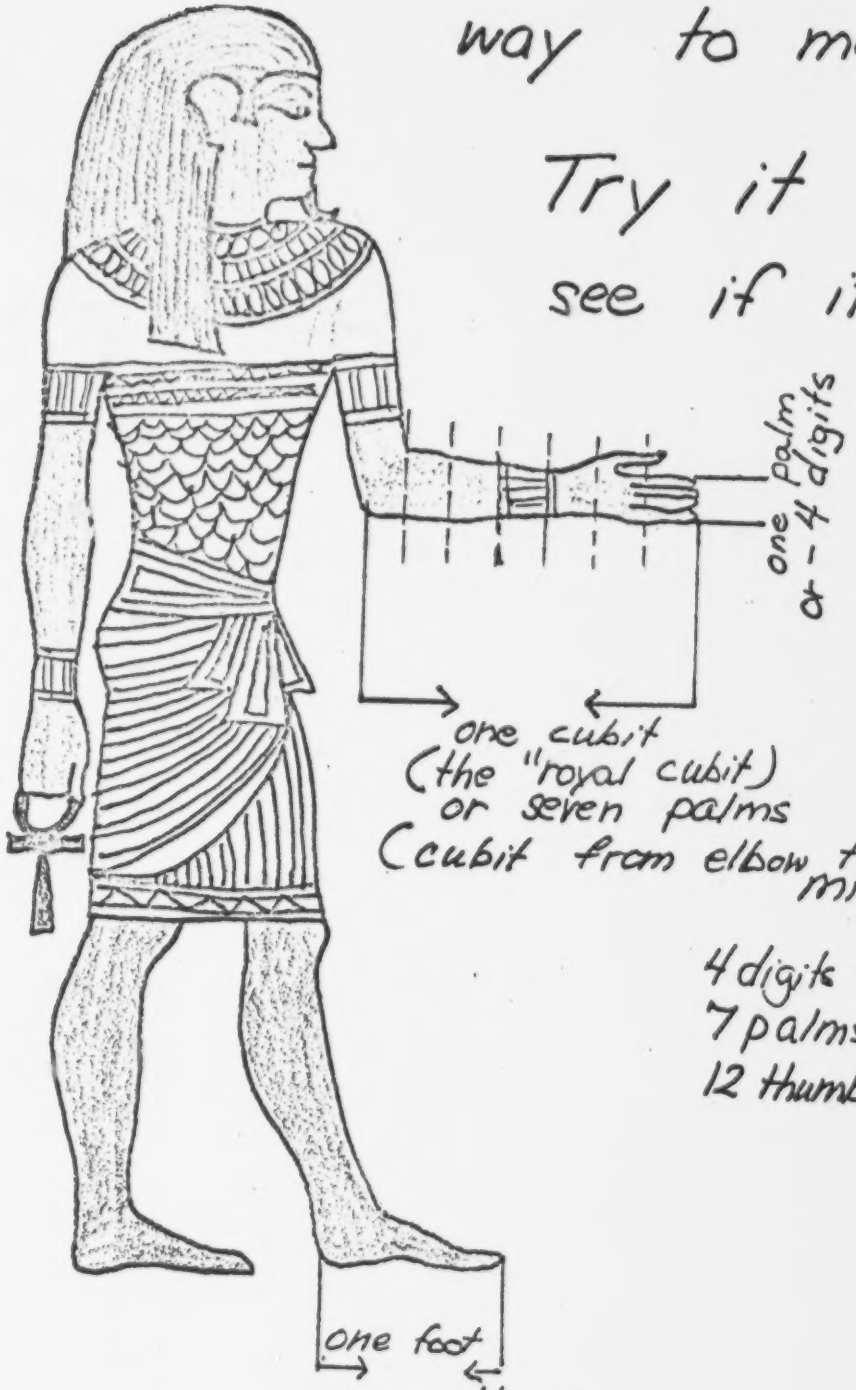
Use different ideas depending on what is available in the class room. Notice some of the above examples are classed "available" which means a child will attempt or can just guess by trying to match. "Not available" means those things in the room which do not lend themselves to this type of mobility. If you wanted to do something like : "This is the length of which window? ; a string length could be wound up and glued down; in which instance the child would have to match the curled string with another or a piece of wire, unwind and then find the straight length of which window.



Plain white paper can be thrown away and replaced with a "new guess"

The Egyptians had a way to measure.

Try it and see if it works



4 digits = 1 palm
7 palms = 1 cubit
12 thumbs = 1 foot

how many thumbs in a cubit?
how many feet in a cubit?
how many palms in a foot?
how many digits in a foot?

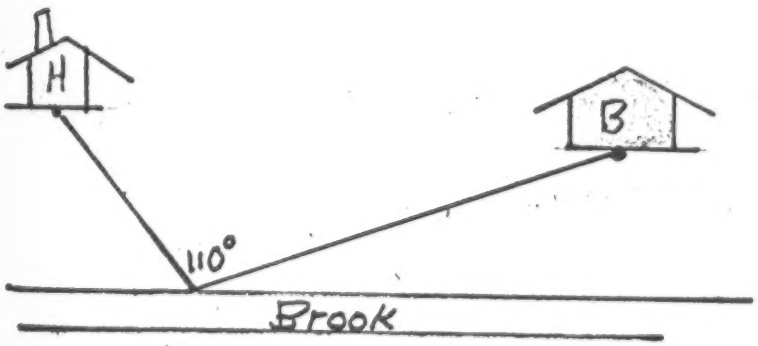
picture after Adler. Giant Golden Book p. 14

CAN YOU SOLVE THIS BY MEASURING? (picture on next page)

Problem: "Farmer Lang likes to take a drink of cool water from the brook each morning on his way to the barn. (See figure). Since he also likes to save steps, he figures out the best path to take to reduce the distance he must walk each day."

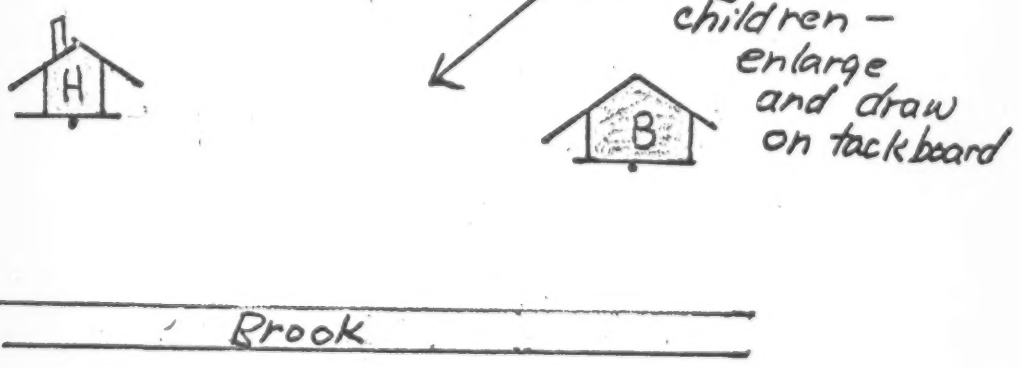
(Ruchlis. The Story of Mathematics. pp. 140-145.

Can you figure the shortest route? Use string, tacks and the tack board. When you think you have it, cut your string the exact length of the path. Tape your name to the string and put up with the others on the bulletin board.



(The above diagram for teacher only)

this diagram for children — enlarge and draw on tackboard

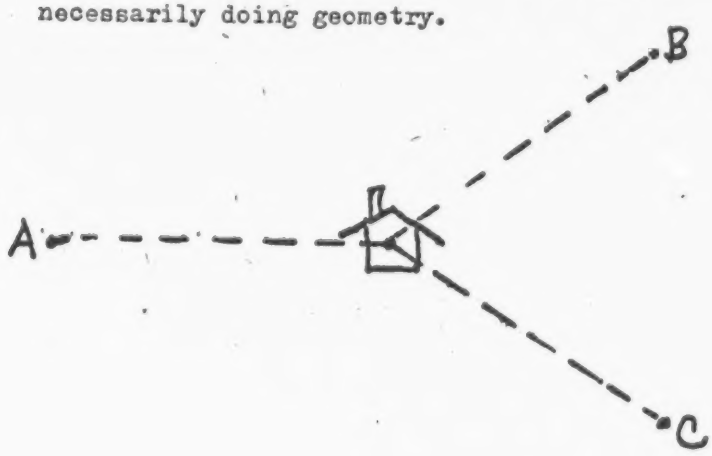


CAN YOU SOLVE THIS BY MEASURING? (picture on next page)

Problem: "Mr. Black is a lawyer who conducts business in three different cities. The figure on the next page shows the location A, B, C of these cities on the map. He wants to build a house located in such a way as to be the same distance from each city so he will be able to drive to all in the same amount of time." (Ruchlis. The Story of Mathematics pp. 140-145.

note to the teacher: The above story will have to be read and explained to the child if necessary. The child can use any method he chooses; however, drawing the "map" as on the next page on tack board and then supplying child with tacks and string is one idea.

The solution below is not given to the child, it is noted simply for the teachers reference. The children are not necessarily doing geometry.



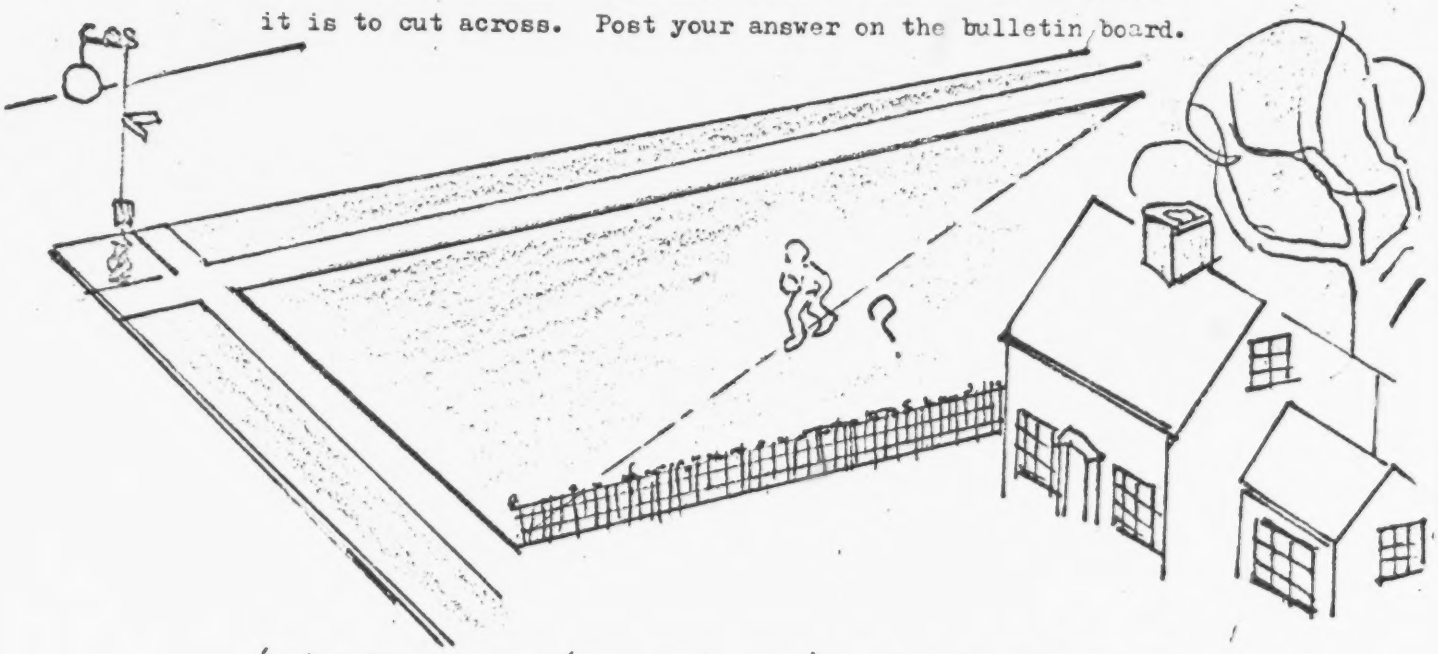
Geometrically solved by drawing a circle which passes through cities A, B, C ...the three routes are radi of one circle.

CAN YOU SOLVE BY MEASURING (con't..."Mr. Black")

enlarge this
diagram for children

THE PROBLEM OF THE SHORT CUT

There is an empty lot next to Sandy's house. The lot has a sidewalk on two sides. The length of the sidewalk is twelve giant steps long (represent one giant step with one toothpick) and nine giant steps wide. When Sandy comes home from school, he cuts across the lot diagonally. How much distance does he save? (note to the teacher: this has to do with the rules of right triangles set forth by Pythagoras; however it is not necessary to understand the rule or even know it to work out the answer) Find out how many giant steps (toothpicks) it would take Sandy to use the sidewalk; then find out how many giant steps to walk diagonally...then find how much shorter it is to cut across. Post your answer on the bulletin board.



(note: draw diagram (see next page) on a large piece of paper, the diagonal should be marked, because children of this age find it difficult to sight and reproduce a straight line. The child has only to measure with tooth picks and do the mathematics...pointing out and defining terminology, discussing the rule (there are two whole number combinations for rt. angled triangles: 3, 4, 5 and 5, 12, 13 and multiples of) and trying other similar problems is up to the abilities of the individual child but it probably will not be significant to any child this age even if he seems to understand)

(problem after Adler. Giant Golden Book of Mathematics. p. 35)

THE PROBLEM OF THE SHORT CUT (con't)

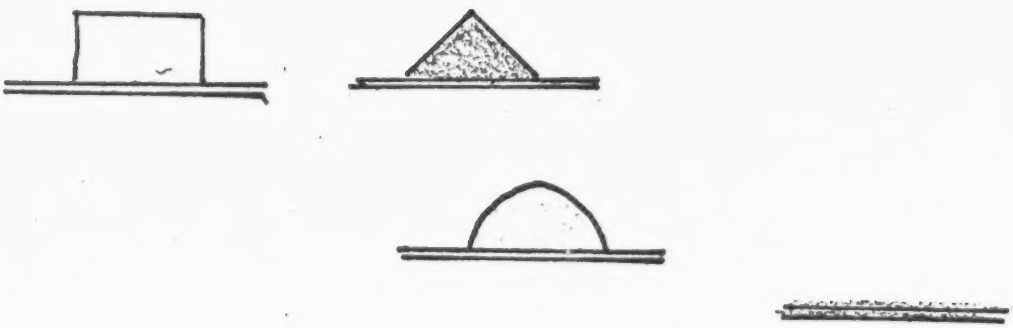
(Enlarge the diagram below on paper large enough to draw the two sides to "toothpick" scale.)

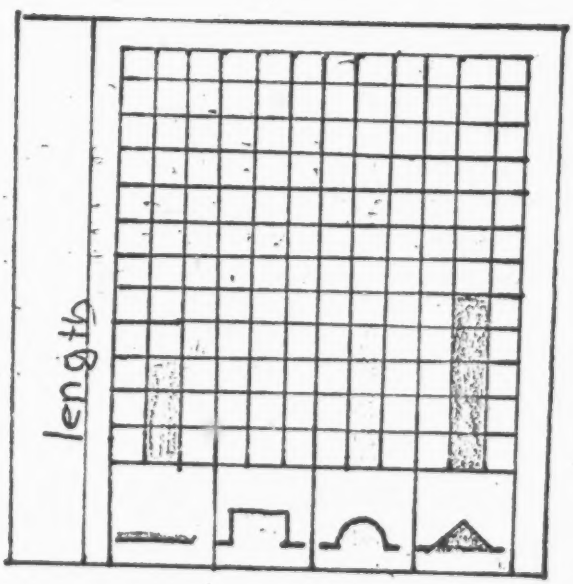
Measure the shortcut with toothpicks
1 toothpick = 1 giant step
how many giant steps to walk straight around the corner on the sidewalk?
How many giant steps to walk the shortcut?
The long way is how many giant steps longer than the shortcut?

OBSTACLE MEASURE

Materials:

1. Paper clips (paper chains or popit beads, i.e., anything flexible which can also be linked together is best suited for this)
2. Obstacles: wooden blocks or anything similar to be set on a flat cardboard; the obstacles for any one set of chart notation should have some interesting relationship e.g., those below are same in base and height.

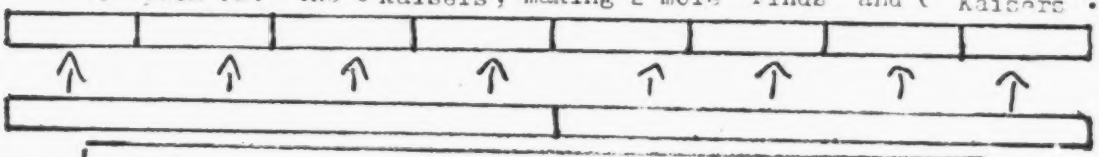




SHELF MATERIAL: Find, Kaiser worksheet

(to be enlarged and run off on mimeo paper)

The children should be provided with many of each increment. In totaling, the child lines up 8 Kaisers...then uses 2 "Finds" to "push out" the 8 Kaisers; making 2 more "Finds" and 6 "Kaisers".



Find = 7 Kaiser = K

1 7 = ___ K

4 K = ___ 7

	7	K
	0	1
	0	1
+	1	1
total		

	7	K
	1	1
	0	2
+	0	3
total		

	7	K
	1	3
	1	3
+	0	2
total		

	7	K
	0	2
	1	2
+	1	1
total		

SHELF MATERIAL: Find, Kaiser, dinky worksheet

(to be enlarged and run off on mimeo paper)

Find = 7 Kaiser = K dinky = d

17 = ___ K	4d = ___ K
17 = ___ d	8d = ___ 7
1K = ___ d	4k = ___ K

	7	K	d
	1	3	2
	0	2	2
+	1	1	0
total			

	7	K	d
	1	3	3
	1	2	1
+	0	1	2
total			

	7	K	d
	0	2	3
	0	1	2
+	0	1	1
total			

	7	k	d
	1	2	3
	0	1	0
	0	0	1
+			
total			

SHELF MATERIAL: Find, Kaiser, dinky, medor worksheet

(to be enlarged and run off on mimeo paper)

Find = 7	Kaiser = K	dinky = d	medor = m
17 = — K	1K = — m	4m = — d	
17 = — d	1d = — m	4d = — K	
17 = — m	64m = — 7	8d = — 7	
1K = — d	16m = — K	4K = — 7	

	7	k	d	m
	1	3	1	1
	0	2	1	3
+	0	0	1	2
total				

	7	k	d	m
	1	0	2	3
	0	3	1	1
+	0	2	2	2
total				

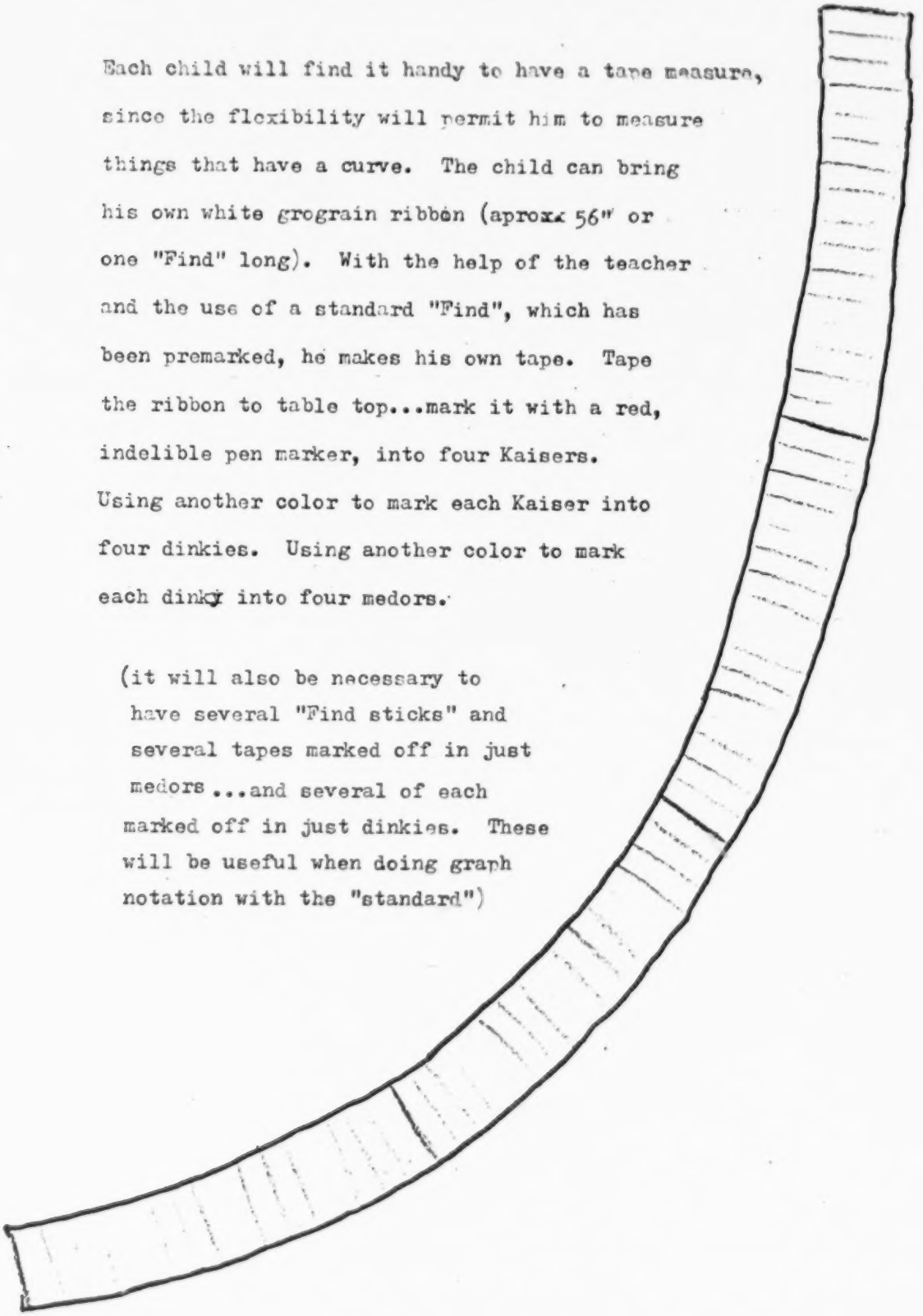
	7	K	d	m
	0	2	3	3
	1	1	2	0
+	1	2	1	1
total				

	7	K	d	m
	0	1	2	2
	1	1	2	2
+	0	3	2	1
total				

SHELF MATERIAL: Tape measures of the standard (a project)

Each child will find it handy to have a tape measure, since the flexibility will permit him to measure things that have a curve. The child can bring his own white grograin ribbon (aproxx 56" or one "Find" long). With the help of the teacher and the use of a standard "Find", which has been premarked, he makes his own tape. Tape the ribbon to table top...mark it with a red, indelible pen marker, into four Kaisers. Using another color to mark each Kaiser into four dinkies. Using another color to mark each dinky into four medors.

(it will also be necessary to have several "Find sticks" and several tapes marked off in just medors ...and several of each marked off in just dinkies. These will be useful when doing graph notation with the "standard")



MAPPING IN FINDS

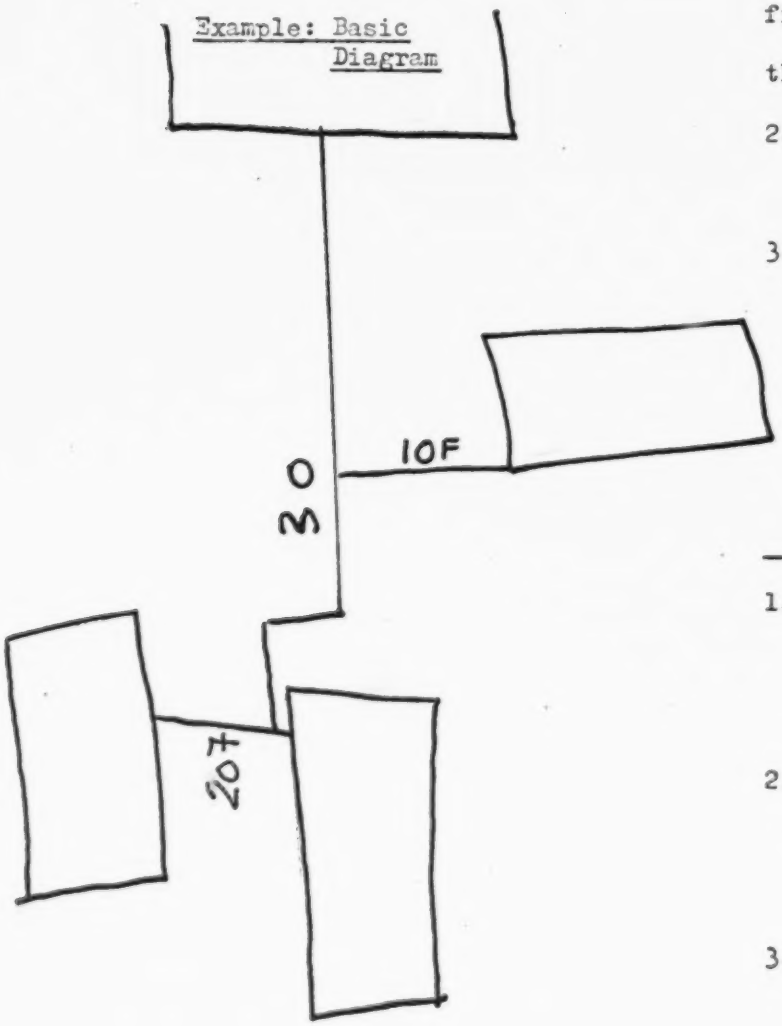
Materials:

1. "Find stick", or "find tape measure
2. a basic diagram
3. large white paper, sissors, colored paper, paste

Exercise:

1. (Note: a comfortable "big step" for a child this age is approximately two Kaisers, 28 inches; therefore, a child may walk off two "big steps" and count it as one "Find", or he may use "little steps", counting each one Kaiser.) Child fills in basis diagram with the number of "Finds".
2. he checks with other to compare results.
3. once three or four children have a similar understanding, they can together begin to do a scaled map (see next page).

Example: Basic Diagram



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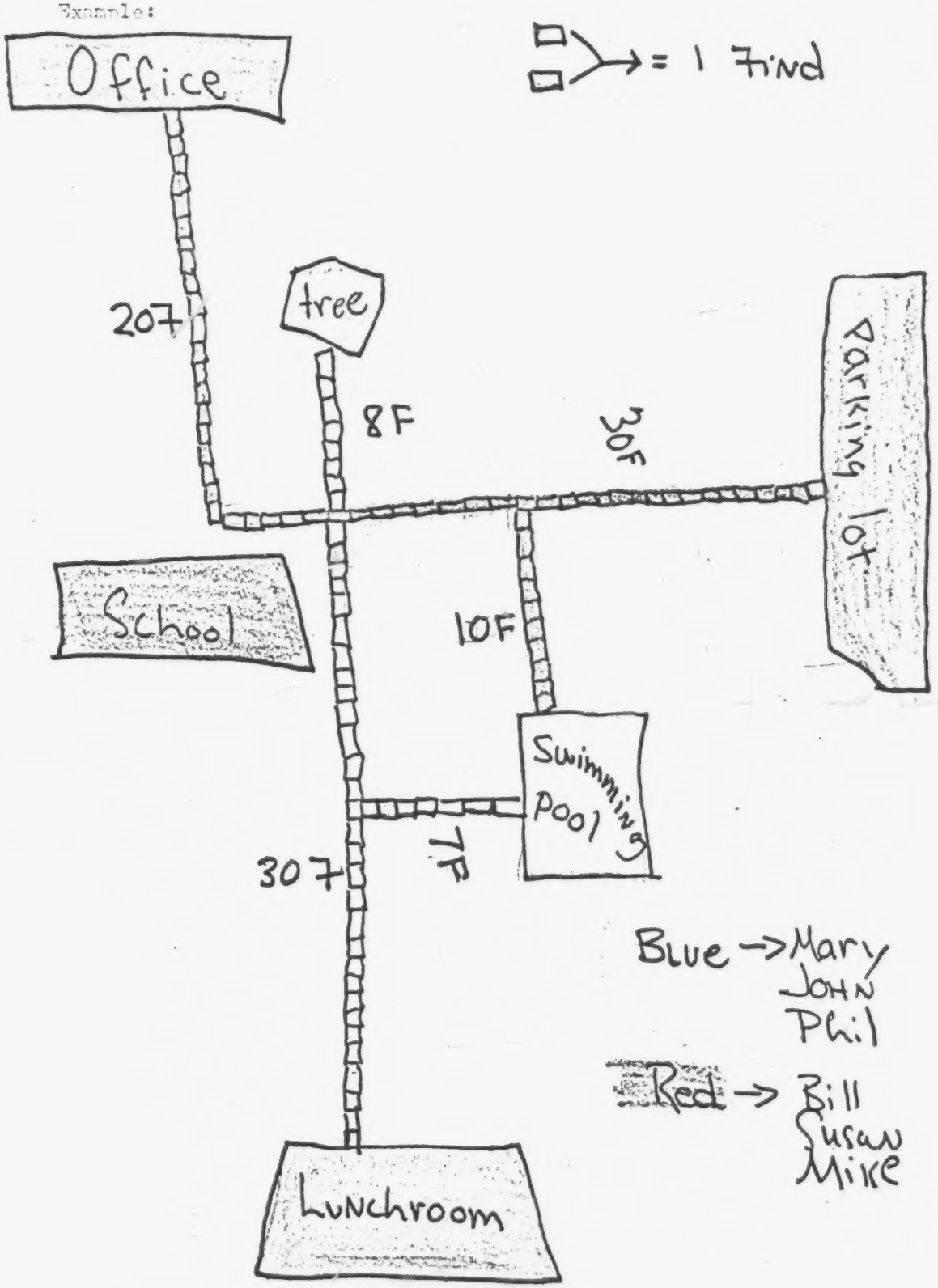
1. on large paper the central place is pasted down.
2. children cut many e.g., inch rectangles which will represent a "Find".
3. the rest is added, see diagram, other chilren may add other things to the same map.

MAPPING IN FIELDS (con't; Diagram map in finds)

Example:



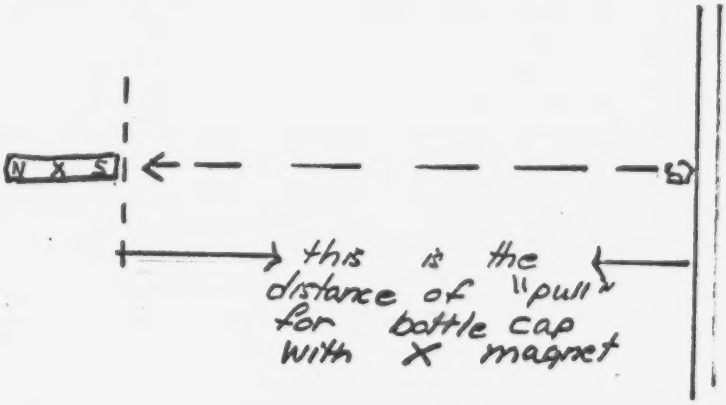
MAGNET STRENGTH

Materials:

1. colored tape
2. different weights; e.g., paper clip, pin, washer, bottle cap.
3. magnets of different strengths

Exercise:

1. on table tape a start line, just in front place a weight e.g., a pin. Holding magnet in hand, move in on the weight until that point when the strength of the magnet starts to pull the weight toward it. Mark the place on the table where the end of the magnet was when the weight began to go to the magnet. Measure that point to the start line (where the weight was) in medors.
2. the chart shows different weights with same magnet...different magnets with same weight can also be done.
   (The magnets can be given a symbol name so that they can be identified.)



using X magnet → distance in medors											
pin	1	2	3	4	5	6	7	8	9	10	11
paper clip	1	2	3	4	5	6	7	8			
tack	1	2	3	4	5						
bottle cap	1	2	3								
→ distance in medors											

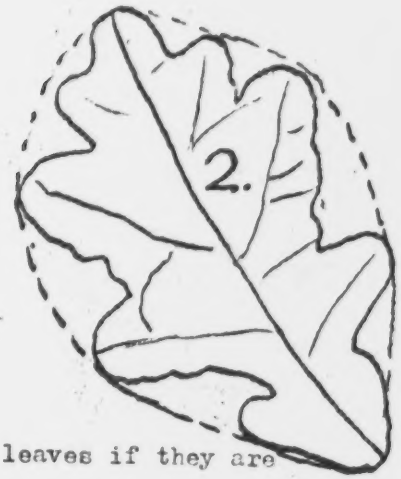
THE PERIPHERY OF LEAVES: CHARTING

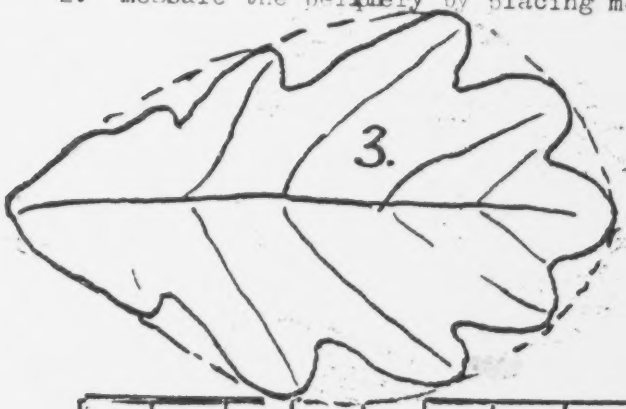
Materials:

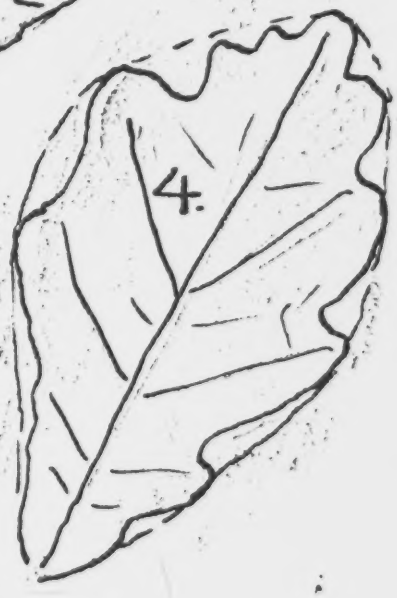
1. leaves from the same tree/or plant
2. leaves from different trees/or plants
3. lots of medors
4. medor graph paper / or other

Exercise:

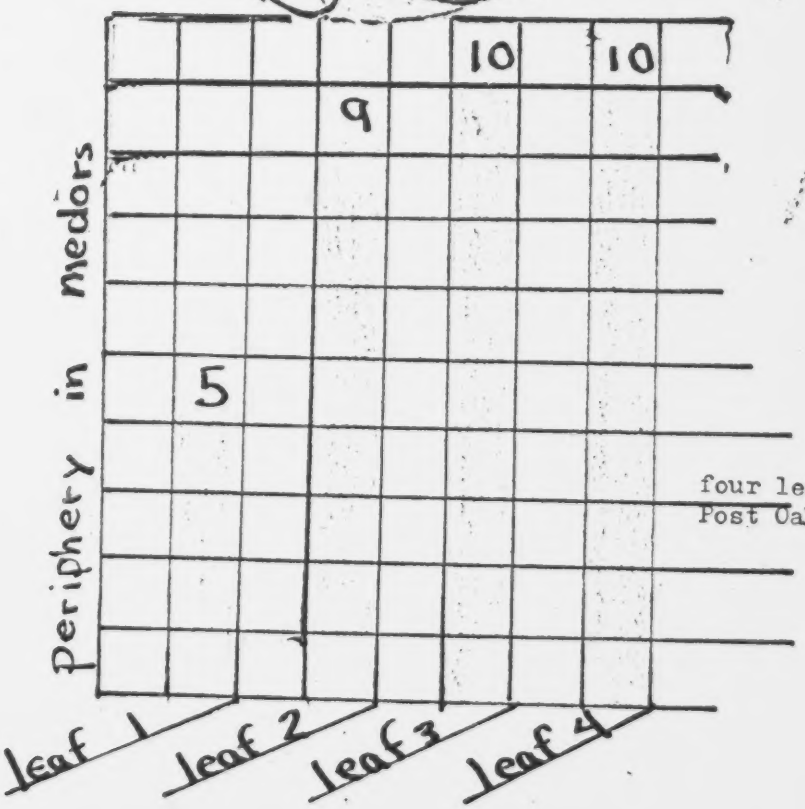
1. make a leaf rubbing...then draw around leaves if they are lobated.
2. measure the periphery by placing medors around the periphery lines.







four leaves from a Post Oak tree



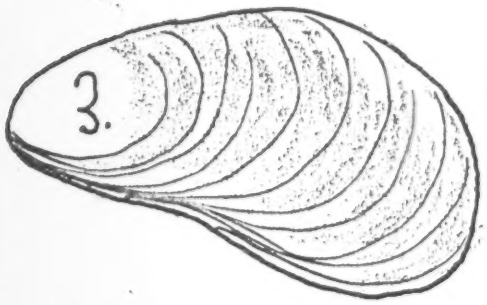
MEASURING SHELLS

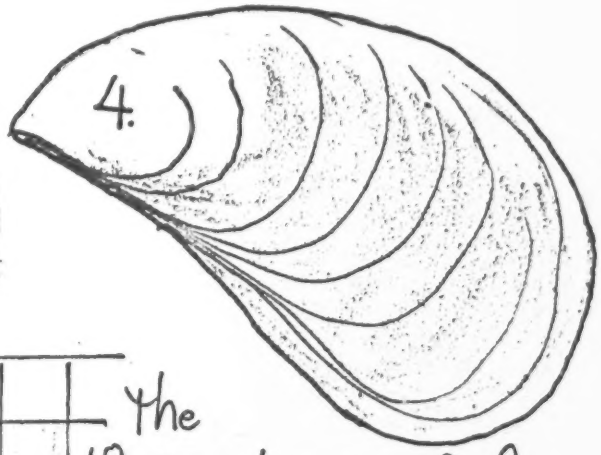
Materials:

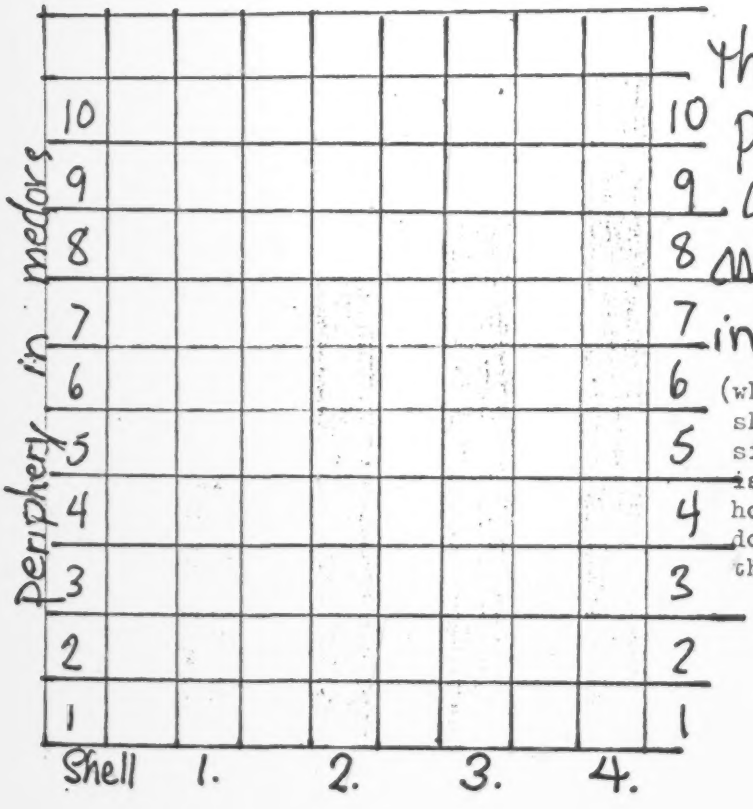
1. several sizes of any bivalves (same or different)
2. thin, flexible wire
3. standard tape measure or a "Find" marked off in medors.
4. squared paper

Exercise:

1. draw around bivalves, or use wire...in the case of snail shells, the wire must be wound in groove of whorl and then stretched out along the meter stick.

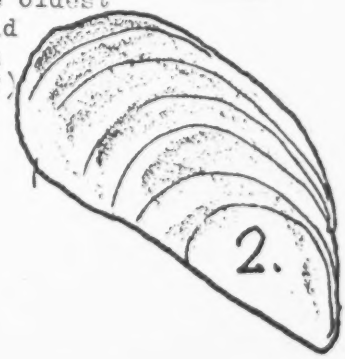






The periphery of four mussel shells, measured in medors.

(why are mussel shells different sizes? Which one is the oldest how old do you think?)

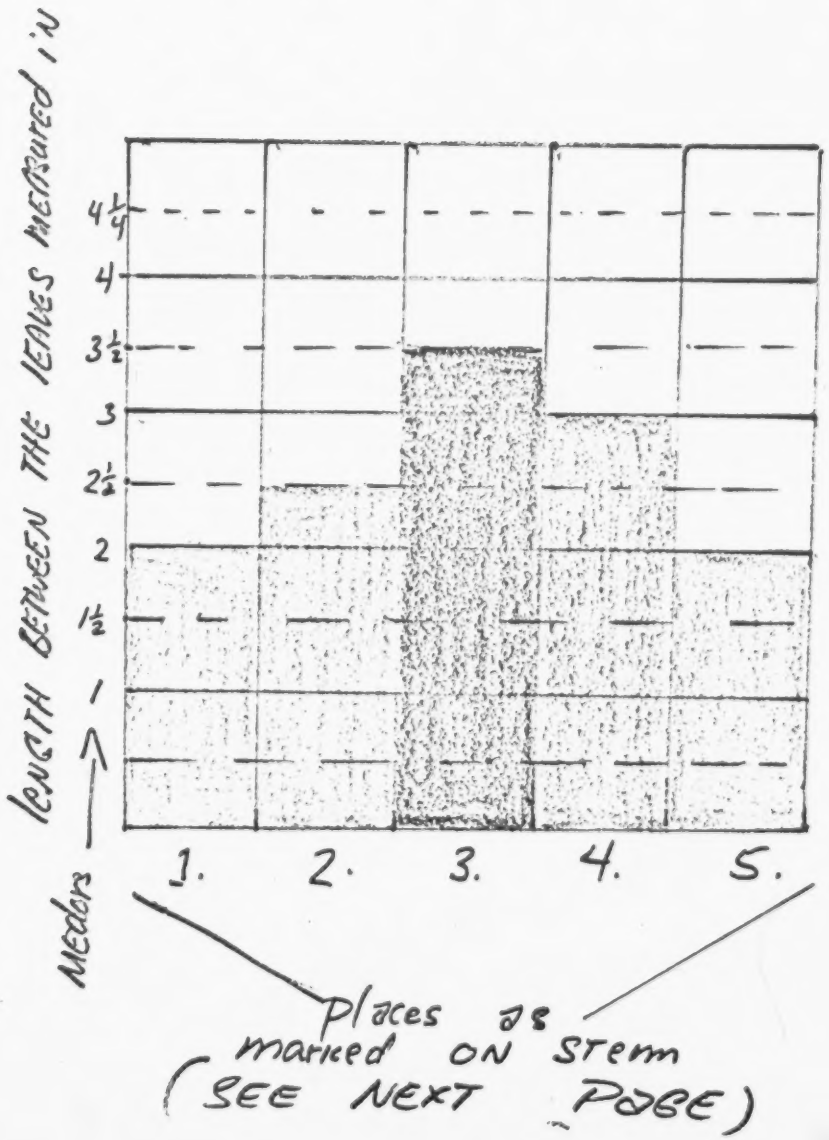


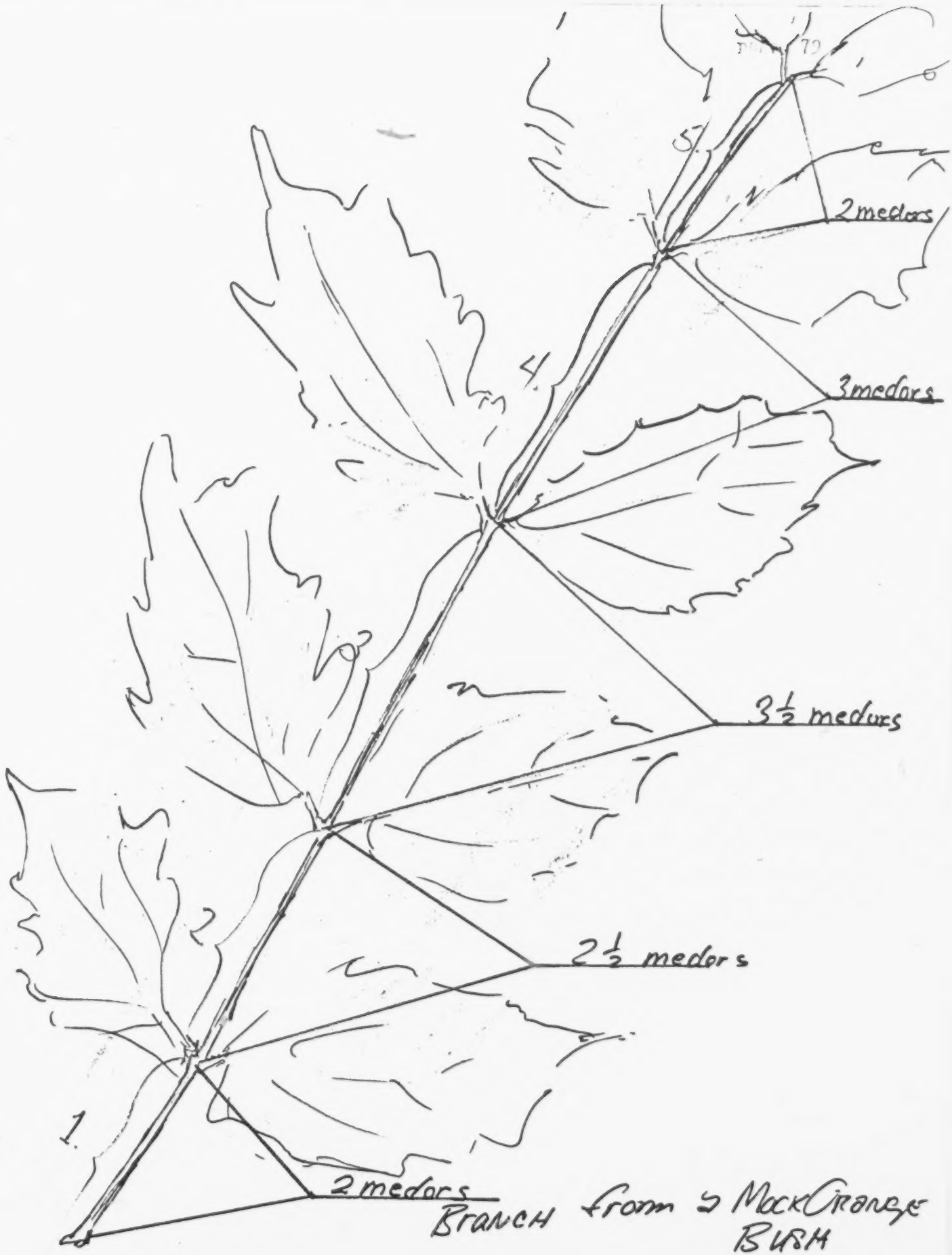
BAR GRAPH OF LEAVES ON A STEM

Materials:

1. A branch from a bush or a small tree (make sure that the spaces between the leaves increase (or differ in size length) to a measurable degree; SEE picture next page).
3. Squared paper.

For the bar chart below SEE the picture of the branch from a mock orange bush on the next page.





BRANCH from a MOCK ORANGE BUSH

THE DIAMETER OF A BALLOON VERSUS TEMPERATURE

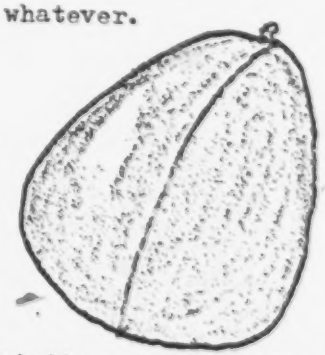
Materials:

1. Refrigerator with freezing compartment.
2. Balloons: The bigger the better---however, the graph shown was done using a five cent balloon, since the freeze compartment would not accommodate any bigger. The measurements were taken on the lengthwise in order to get the greatest possible variation in diameter.
3. String
4. Paperclips and tags for string lengths
5. A Find stick marked off in medors; for measuring the string.

Project:

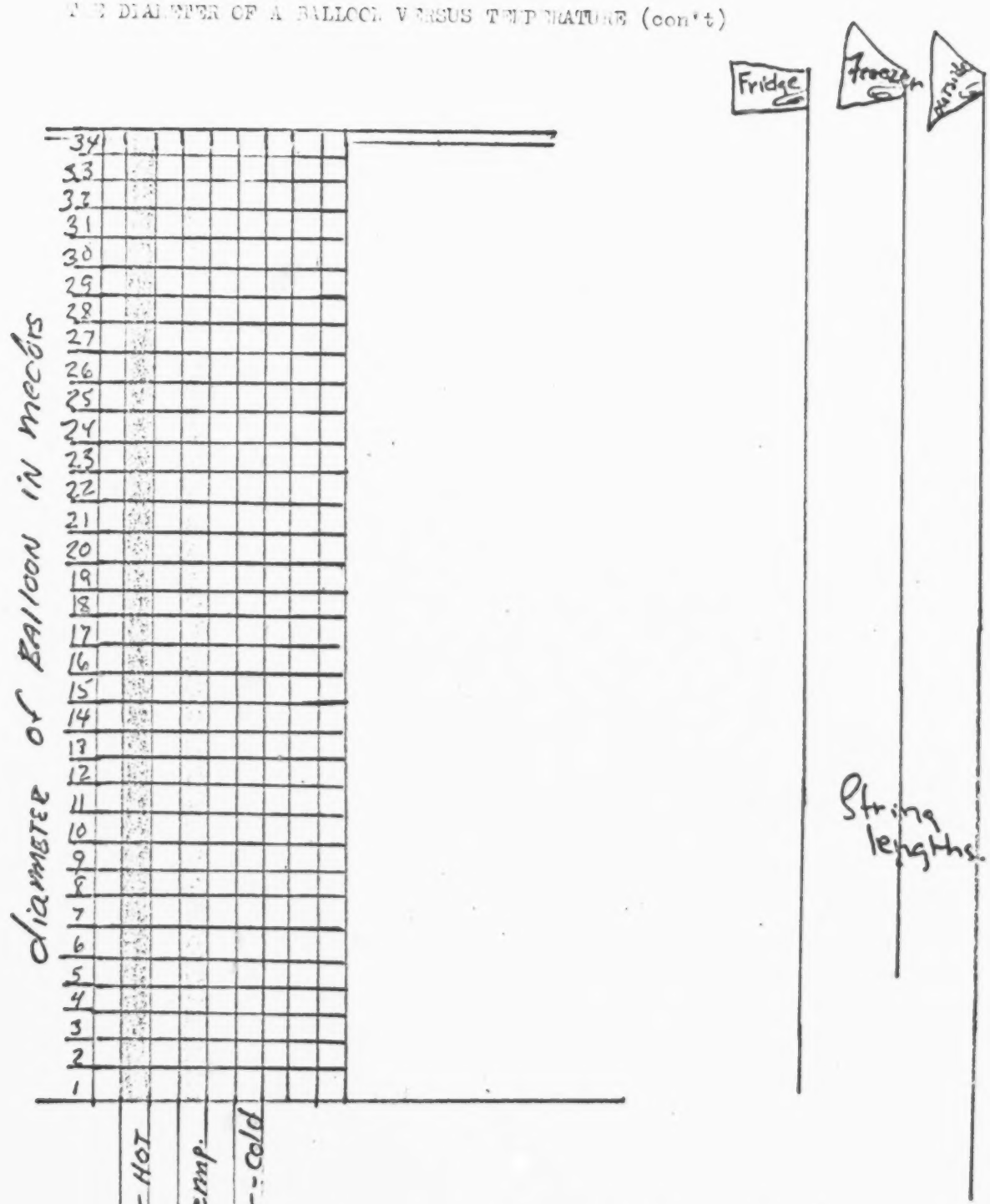
(blow up the balloon and take the original measurement; in case at some stage the balloon pops. Tag that string "original".)

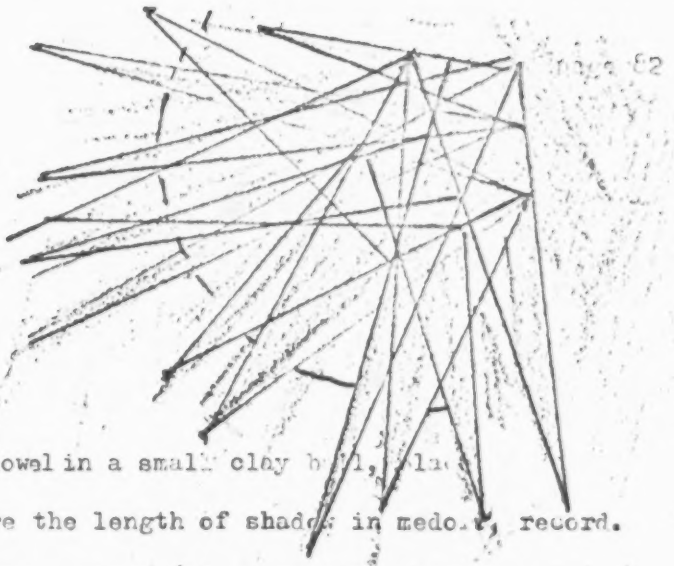
1. Blow up the balloon (be sure it has some give in it), mark with a felt tipped pen around the greatest diameter (the string will always be placed over this line when measuring). The first measurement will be taken from the freezer. Place balloon in the freezing compartment and leave for about an hour. Measure the diameter, without really removing the balloon from the freezer (if you remove it will immediately enlarge). Clip the string and place a tag "freezer".
2. Place the balloon in the refrigerator "proper" after an hour take the measurement, without removing balloon. Tag the string refrigerator.
3. Now hand balloon outside, on a warm day in the sun, or just in a place that is considerably warmer than the refrigerator. You will be able to measure the increase in diameter quite soon since the air in the balloon expands rather rapidly. Tag the string "outside" or "in sun" or whatever.
5. The three strings should then be laid against a Find stick, marked off in medors. Find the length of the diameter in medors or the three strings.



(NOTE: the sequence in the directions above is necessary to obtain significant variations in diameter, the reason being, that you are originally blowing hot air into the balloon)

THE DIAMETER OF A BALLOON VERSUS TEMPERATURE (con't)





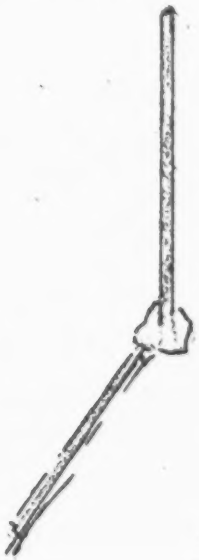
MEASURING SHADOWS

Materials:

1. stick in clay
2. meter stick or tape
3. squared paper

Exercise:

1. place a straw or thin dowel in a small clay ball, place outside in sun...measure the length of shadow in meters, record.
2. the children can be shown a clock (they probably know how to tell the hour); but they will have to be reminded to record the length of the shadow every hour.



lenght of shadow in meters	9 o'clock	10 o'clock	11 o'clock	12 o'clock	1 o'clock	2 o'clock	3 o'clock
6.	6.						6.
5.	5.	5.				5.	5.
4.	4	4	4.		4.	4.	4.
3.	3	3.	3.	3.	3.	3	3.
2.	2.	2	2.	2.	2	2.	2.
1.	1	1	1.	1.	1.	1.	1.

HEIGHT VERSUS DISTANCE (perspective)

Materials:

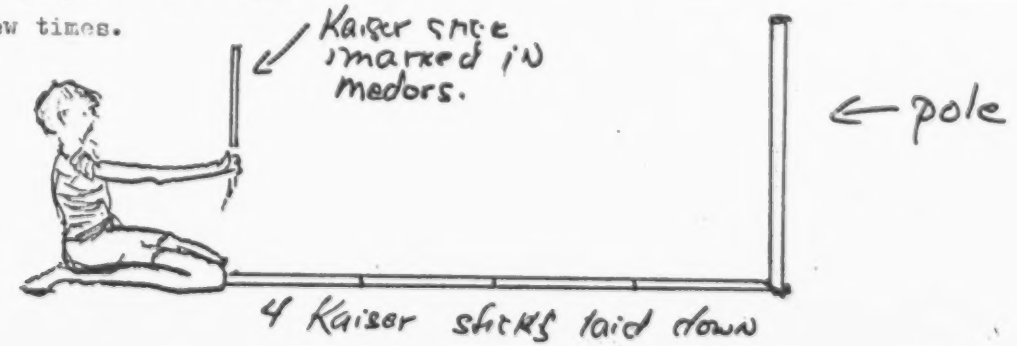
1. Notation paper and pencil
2. Find stick measured in medors
3. Kaiser stick measured in medors
4. Graph paper (squared paper)

Project: (Note: teacher supervision will be necessary to keep the accuracy and the system the same at each move.)

1. Select a pole or erect one in the ground or in the room. It should measure approximately 32 medors.
2. Measure two Kaisers away from it. Now measure the height of the pole.
   (Remember to always hold the same position each time the height is measured. The best way found was to kneel, sitting on heels, then hold the Kaiser stick (measured in medors) in left hand with arm and back stretched as far as they will go. This position is one that can easily be regained each time a new measurement is taken.
3. Close one eye and size up the height of the pole in medors. Have a partner do the notations.
4. The measurements of a pole (which was 32 medors) are given at the right.

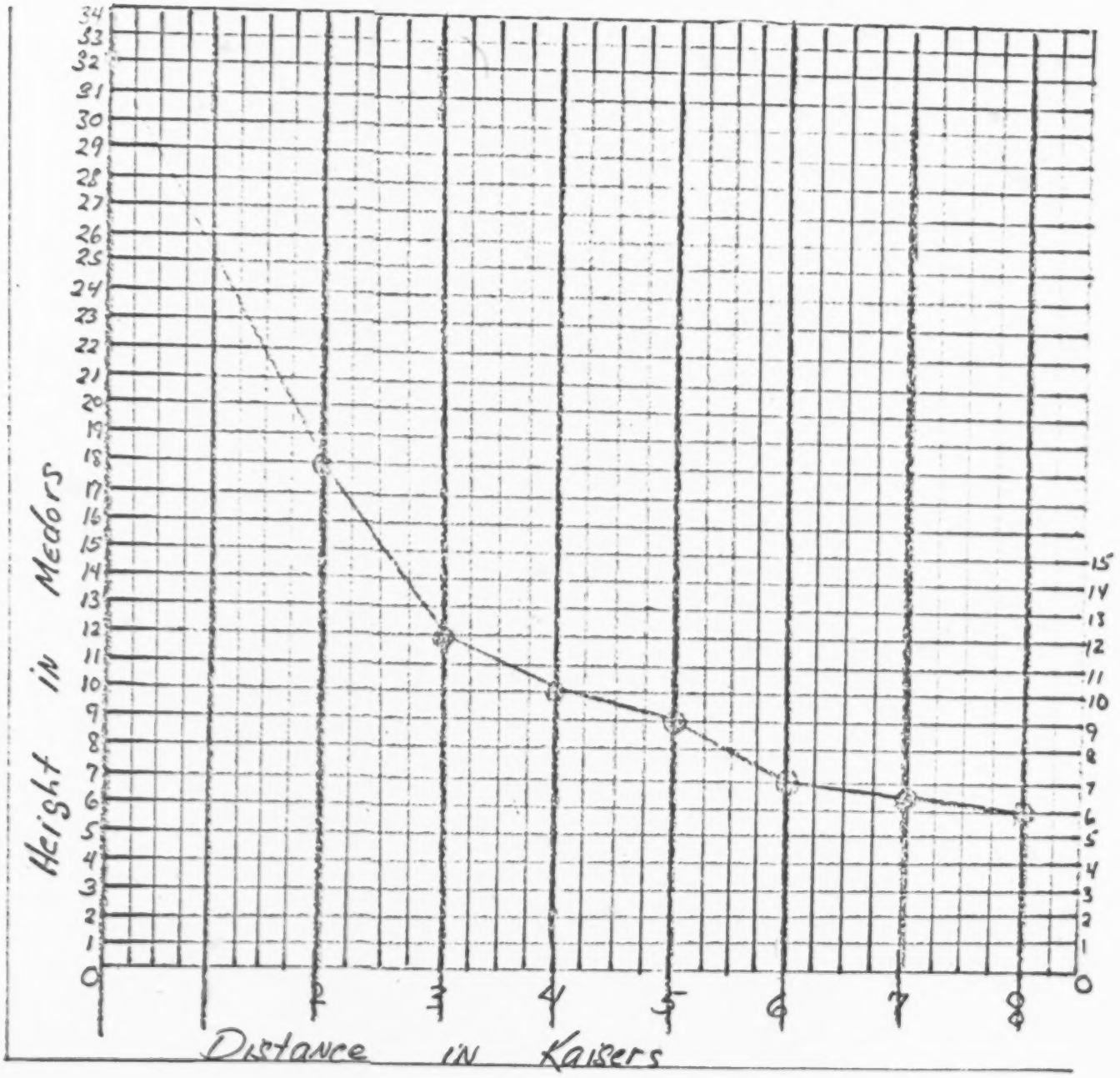
The graph obtained from these measurements is given on the next page. A teacher will need to help out with this type of graph on the first few times.

Distance in Kaisers	Height in medors
0 Kaisers	32 medors
2 Kaisers	18 medors
3 Kaisers	12 m
4 K	10 m
5 K	9 m
6 K	7 m
7 K	6½ m
8 K	6 m



HEIGHT VERSUS DISTANCE (con't)

This graph gives the height of a 32 medor pole at distances in Kaisers.



It should be interesting to do the same with different heights, one idea would be to use a child in place of the pole. Compare the graphs to see if the same type of curve is always apparent. (note: this same thing could be done just as a bar chart)

THE CASE OF THE VANISHING BAR OF SOAP

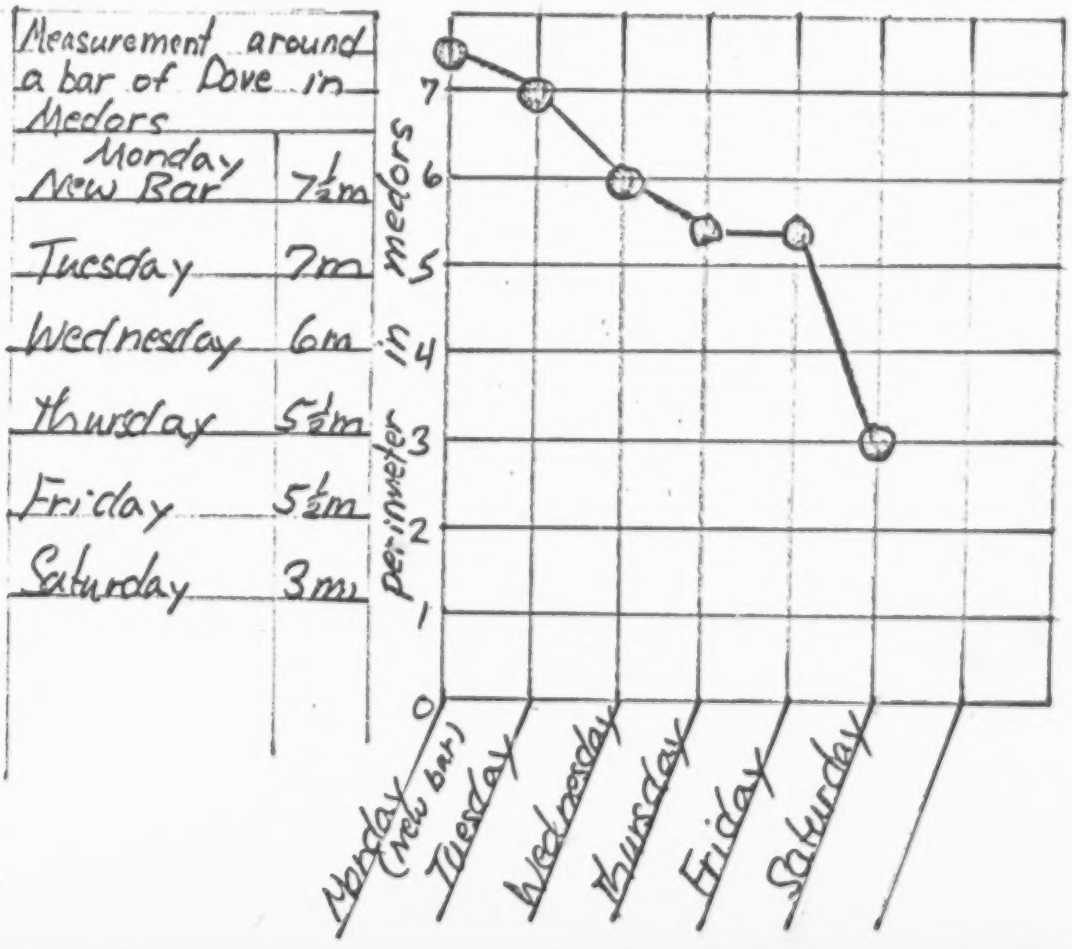
Material:

1. Medor measuring tape
2. A hand size bar of soft soap (Dove or Ivory)
3. Notation paper
4. Squared paper

Project:

1. Measure around the new bar of soap.
2. The child then takes home for general family use; or just for his own baths; or it can remain at school for class use.
3. Every morning (or evening), the child measures around the bar of soap with his medor tape; and writes how big the bar of soap is in medors next to the day. He does this until the bar is no longer measurable.
4. Graph results.

(this could also be done with a chunk of ice melting in the classroom)



HOW MUCH WATER BOILS AWAY?

Materials:

1. Stove or hot plate
2. Narrow vessel in which to boil water (the narrower the better; this experiment was done with a 4½" container with an original water content of 3 medors deep)
3. A Kaiser stick marked in medors
4. Record sheet
5. A timer
6. Squared paper

Project:

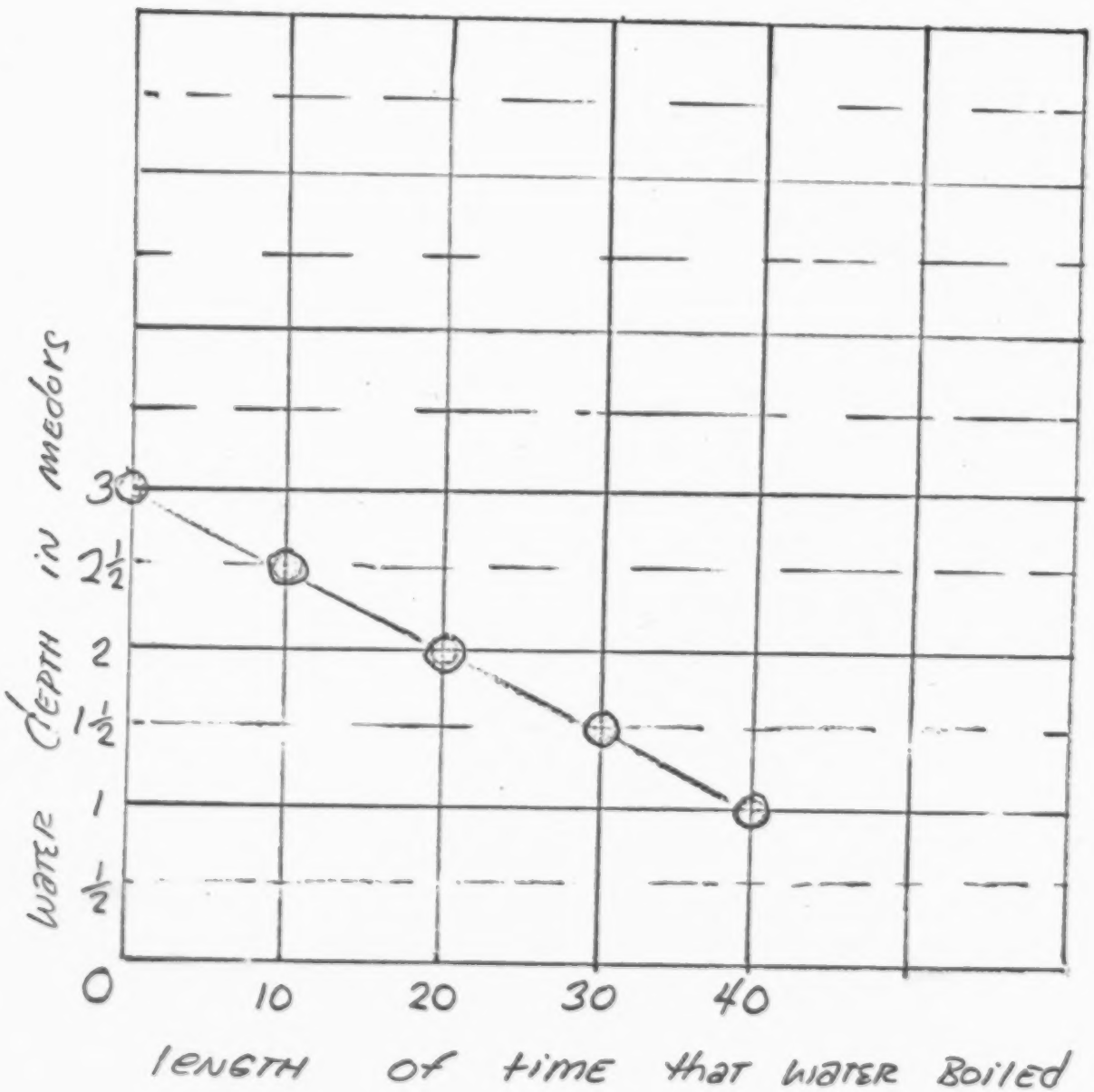
1. Measure water into a container for boiling; as many medors deep as the vessel will hold (but leave at least an inch at the top so that it will not boil over)
2. Mark on notation paper: e.g. 0 minutes-----3 medors
3. Wait for water to come to a rolling boil
4. Set timer for 10 minutes (or whatever time increment you choose to use.)
5. When the timer goes off---measure the depth of the water with the Kaiser stick marked in medors. Record: e.g. 10 minutes---2½ medors
6. Set the timer again for another 10 minutes; when it goes off, measure the depth of the water again and record:
   e.g. 20 minutes---2 medors
7. Repeat the above instructions until you have enough information to work with:

Record Sheet
0 minutes - 3 medors
10 minutes - 2½ medors
20 minutes - 2 medors
30 minutes - 1½ medors
40 minutes - 1 medor

(SEE GRAPH ON NEXT PAGE)

HOW MUCH WATER BOILS AWAY? (con't)

This is the graph made from the record sheet on the previous page. The vessel used for boiling was $4\frac{1}{2}$" wide. The water boiled for a total of 40 minutes. The depth of the water was taken every 10 minutes with a medor stick.



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Ford Educational Affairs Dept. History of Measurement (a giant wall poster showing in 8" x 11" children's type pictures the history of Measurement) available without charge from:
Ford Educational Affairs Dept.
The American Road
Dearborn, Michigan